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Canada

Editorial

Reducing premature mortality among young and middle-aged adults

Joel G. Ray, MD, FRCPC (1,2,3)

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The death of an individual in early and middle adulthood is an untimely event whose tragic effects are experienced by the parents, siblings, partners, children[1-3] and friends of the deceased individual. Preventing premature death is a foremost goal of health care and public health programs, and of society at large.

Premature mortality is a measure of unfulfilled life expectancy. While conventional definitions of premature mortality and Years of Potential Life Lost[4] include all people from birth to age 65[5] or 75[6] years, such designations obscure our understanding of factors preventable in adulthood. For example, deaths in childhood largely occur in infancy—due to birth defects and preterm birth. At the other end of the lifespan, by including seniors aged 65 to 75 years—who account for the greatest number of deaths—the cause of death is skewed toward cancer and cardiovascular disease. Among Canadians of all ages, the top five causes of death are cancer (30%), heart disease (21%), stroke (6%), lung disease (5%) and unintentional injury (4%).[7] However, upon restricting to Canadians aged 25 to 34 years, the top five leading causes of death shift to unintentional injury (29%), suicide (20%), cancer (12%), heart disease (5%) and homicide (5%).[7] For those aged 35 to 44 years, the top five leading causes of death include unintentional injury, suicide and liver disease, the latter often due to alcohol overuse and injection drug use. In Toronto, the causes of premature death follow the same pattern.[8]

Of all deaths occurring among Canadians aged 20 to 64 years, 20% are among those aged 20 to 44 years.[9] Most premature deaths in young and middle-aged adults are also highly preventable. About 6% of all these deaths in Canada are alcohol-related—more than twice as much for men (7.6%) as for women (3.5%).[10] In Russia, where alcohol consumption has emerged as a major public health concern, it is estimated that 43% of reported deaths among males aged 25 to 54 years are attributable to hazardous drinking.[11] In Ontario, in 2010, one in eight deaths among adults aged 25 to 34 years was opioid-related,[12] and across the country we see the unfolding of an opioid epidemic that has consumed, and then ended, the lives of so many Canadians.

Mental illness and criminal behaviour are also interconnected in their effect on premature mortality. Within two large Swedish studies of 15 337 adults with bipolar disorder, age- and sex-matched to 20 adults randomly sampled from the general population, 22% engaged in suicidal or criminal acts after bipolar disorder diagnosis, compared with 4.6% of those in the general population (adjusted relative risk [RR] 3.0, 95% confidence interval [CI] 2.9–3.2).[13] People with bipolar disorder had a risk of suicide 14.6 (95% CI: 12.1–17.6) times higher, especially those with a history of attempted suicide, or an alcohol- or drug-use disorder.[13] Among 475 delinquent and 456 matched nondelinquent boys followed from age 14 to age 65 years, 6.1% versus 2.4%, respectively, died unnatural deaths before age 40 years. This outcome was predicted by juvenile antisocial behaviour and alcohol overuse, and the deaths were most likely from homicide and poor self-care.[14] Among repeat criminal offenders in Finland, the risk of death before age 30 years is 29 times higher than that for nonoffenders.[15] Of those who experience incarceration within a Canadian provincial correctional facility, the standardized mortality ratio is 4.0 (95% CI: 3.9–4.1), with injury and poisoning accounting for 38% of all deaths,[16] and the most pronounced RRs among the youngest offenders, especially women.[16] We see similar statistics for those in a Canadian federal correctional facility.[17] Thus, it is apparent that some adults prone to premature death are caught in a web of mental illness, substance use and criminality, often starting from youth.

There are some "generic risk factors" for premature mortality due to intentional and unintentional causes, especially risk factors clustered around mental illness. Neeleman systematically examined 163 cohorts and found that several known risk factors for suicide—including prior deliberate self-harm, alcohol and drug misuse and severe mental illness—were also associated with nonsuicidal death.[18] Lai et al. evaluated 22 epidemiological survey studies of the prevalence of psychiatric illness in people with a substance-use disorder.[19] Those with an illicit drug-use disorder had higher odds of major depression (3.8 times higher [95% CI: 3.0–4.8]) and higher odds of an anxiety disorder (2.9 times higher [95% CI: 2.6-3.3]). The odds ratios among people with an alcohol-use disorder were 2.4 (95% CI: 2.2–2.6) and 2.1 (95% CI: 2.0–2.2), respectively. Hence, we can use

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these generic risk factors – including prior deliberate self-harm, substance use and severe mental illness – to identify adults at risk for premature mortality, of which several are amenable to intervention, even starting in childhood.[18]

It is no coincidence that the increasing prevalence of addiction to hyperpalatable obesogenic foods[20] and the emergence of "globesity"[21] have led many to view obesity as a noncommunicable disease, and one whose major impact on premature mortality has yet to be realized.[22] Those predisposed to food addiction also tend to have higher depression scores,[20] a greater likelihood of having been abused as a child[23] and less access to physical activity facilities, especially in areas with low socioeconomic status and among certain minority groups,[24] including Indigenous children and youth.[25] Certainly, acknowledgement of and proper accounting for these and other inequities can help young adult populations to achieve a healthier body mass, as highlighted in the current issue of *Health Promotion and Chronic Disease Prevention in Canada*, by Bhawra et al.,[25] Frankish et al.[26] and Rao et al.[27]

In another paper published in the current issue, Steensma and colleagues present national data on health-adjusted life expectancy (HALE)—a hybrid measure not only of quantity of life, but of quality of life as well.[28] Across Canada, about 45% of the variation of HALE by health region was previously explained by differences in socioeconomic status,[29] and Steensma et al. suggest that things may be worse in Newfoundland and Labrador and Prince Edward Island, especially among males.[28] This analysis may in fact be conservative, considering that the data were available only up to 2010, and the study could not include people living on Indian reserves, certain remote areas of Ontario and Quebec and within the three Canadian territories—areas where disability-free life expectancy (a metric similar to HALE) tends to be worse.[29] Certainly, a consideration of HALE that specifically focusses on those aged 20 to 45 years can reveal the degree to which some of the factors that influence premature loss of life also concomitantly reduce quality of life in early and middle adulthood.

Dealing with premature mortality among young and middle-aged Canadians starts with a clear definition of who is at highest risk, the likely predisposing factors and some sensible solutions that are multipronged, evidence-based and realistic. Alongside completed and ongoing research in the treatment of mental illness and addictions, as well as the primary and secondary prevention of intentional and unintentional injury, we should expect not only to reduce the number of premature deaths in Canada, but to enhance the well-being of those whose lives are spared from such an untimely fate.

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Evaluating compression or expansion of morbidity in Canada: trends in life expectancy and health-adjusted life expectancy from 1994 to 2010

Colin Steensma, MSc (1,2); Lidia Loukine, MSc (1); Bernard C. K. Choi, PhD (1,3,4)

This article has been peer reviewed.

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Abstract

Introduction: The objective of this study was to investigate whether morbidity in Canada, at the national and provincial levels, is compressing or expanding by tracking trends in life expectancy (LE) and health-adjusted life expectancy (HALE) from 1994 to 2010. "Compression" refers to a decrease in the proportion of life spent in an unhealthy state over time. It happens when HALE increases faster than LE. "Expansion" refers to an increase in the proportion of life spent in an unhealthy state that happens when HALE is stable or increases more slowly than LE.

Methods: We estimated LE using mortality and population data from Statistics Canada. We took health-related quality of life (i.e. morbidity) data used to calculate HALE from the National Population Health Survey (1994–1999) and the Canadian Community Health Survey (2000–2010). We built abridged life tables for seven time intervals, covering the period 1994 to 2010 and corresponding to the year of each available survey cycle, for females and males, and for each of the 10 Canadian provinces. National and provincial trends were assessed at birth, and at ages 20 years and 65 years.

Results: We observed an overall average annual increase in HALE that was statistically significant in both Canadian females and males at each of the three ages assessed, with the exception of females at birth. At birth, HALE increased an average of 0.2% ($p = .08$) and 0.3% ($p < .001$) annually for females and males respectively over the 1994 to 2010 period. At the national level for all three age groups, we observed a statistically non-significant average annual increase in the proportion of life spent in an unhealthy state, with the exception of men at age 65, who experienced a non-significant decrease. At the provincial level at birth, we observed a significant increase in proportion of life spent in an unhealthy state for Newfoundland and Labrador (NL) and Prince Edward Island (PEI).

Conclusion: Our study did not detect a clear overall trend in compression or expansion of morbidity from 1994 to 2010 at the national level in Canada. However, our results suggested an expansion of morbidity in NL and PEI. Our study indicates the importance of continued tracking of the secular trends of life expectancy and HALE in Canada in order to verify the presence of compression or expansion of morbidity. Further study should be undertaken to understand what is driving the observed expansion of morbidity in NL and in PEI.

Keywords: life expectancy, health expectancy, compression, expansion, mortality, morbidity, trend, health-related quality of life

Highlights

- Life expectancy (LE) and health-adjusted life expectancy (HALE) increased consistently from 1994 to 2010 for both Canadian females and males.
- HALE gains observed in the Canadian population over the reporting period were primarily associated with a decrease in mortality.
- The Canadian population appeared to be experiencing a period of relative stability in health expectancy from 1994 to 2010: no clear overall trend in compression or expansion of morbidity for the reporting period was detected in Canada.

Introduction

Two major potential scenarios have been proposed for future mortality and morbidity patterns. The "compression of morbidity" scenario anticipates an increase in life expectancy (LE) and a decrease in the proportion of life spent with serious disease and disability.[1-3] This is possible when shifts in future disease patterns delay disease onsets to older ages. People will live longer (due to reduced mortality) with reduced morbidity.

The "expansion of morbidity" scenario anticipates an increase in the life expectancy and an increase in the proportion of life spent with underlying illness or disability.[4,5] This is achieved when medical

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advances reduce mortality and case fatality but the disease patterns remain the same. Improved medical care increases survival and enables individuals to live despite illness. People will live longer (due to reduced mortality) but with increased morbidity and duration of morbidity. Determining which of these scenarios predominates will provide important information on the overall disease burden for health jurisdictions, with implications for strategic planning for future health care services and delivery.

Health expectancy, defined as life expectancy in a defined state of health,[6,7] is an important tool for monitoring trends in population health and for evaluating the evidence for the compression or expansion of morbidity scenarios. A useful metric of health expectancy is "health-adjusted life expectancy" (HALE), defined as the average number of healthy years that a person would live under the mortality and morbidity prevailing at that time.[8]

Studies evaluating recent national trends in health expectancy within economically developed jurisdictions[9,19] have shown evidence for both scenarios: some countries and autonomous regions appear to be experiencing an expansion of morbidity[9,12] while others indicate a compression of morbidity.[13,16] One country demonstrated scenarios that differed by age group.[17] In Canada, studies of health expectancy trends at the national level have given mixed results. One study reported a period of morbidity expansion from 1986 to 1991 followed by compression from 1991 to 1996,[18] while another comparing health expectancy in 1994 and 2007 suggested an overall expansion of morbidity between those two reporting periods.[19]

One of the challenges of assessing trends in health expectancy from available national surveys is the lack of consistent data over time. Many of the existing studies have evaluated trends using different disability measures across reporting periods[12,15,16] and/or a limited number of reporting periods.[11,16,17,19]

Another challenge is that only a few evaluations of trends in health expectancy have been done at the sub-national level.[20–22] At the provincial level in Canada, a study in Quebec[22] found a larger proportion of life with disability in 1998 as compared to 1986, which suggests an expansion of morbidity during this period. In Canada, provincial estimates of health expectancy trends are a useful starting point for public health decision makers to plan resource allocation, since this is the jurisdictional level where health care is implemented.

The purpose of this study was to evaluate changes in health-adjusted life expectancy (HALE) in the Canadian population for the period 1994 to 2010 using multiple cycles of nationally representative surveys that have similar design and employ the same measure of functional health (Health Utilities Index). Specifically, we assessed trends in expansion or compression of morbidity by measuring changes in proportion of life spent in an unhealthy state. These trends were assessed at birth, at age 20 years and age 65 years, by sex and by province.

Methods

We used mortality and population data from Statistics Canada to estimate life expectancy for seven time intervals that covered the period 1994 to 2010 and which corresponded to the years in which the survey data required to calculate HALE were available (described later on in this section). For HALE, additional self-reported morbidity data came from the Health Utilities Index (HUI) component of the National Population Health Survey (NPHS) and the Canadian Community Health Survey (CCHS) conducted by Statistics Canada.

Both the NPHS and the CCHS were designed to collect information on the health of the Canadian population residing in households. During the first three cycles (1994/95, 1996/97 and 1998/99) the NPHS contained both cross-sectional and longitudinal components. Beginning in 2000, the cross-sectional component of NPHS was taken over by CCHS. For this reason, we used NPHS cross-sectional data for the period of 1994 to 1999 and CCHS data for the period of 2000 to 2010.

The first cycle of the NPHS data collection took place in 1994/95 and continued every second year thereafter. Its initial core sample was 17 276 individuals living in Canada's 10 provinces.[23] The household response rates for the cross-sectional component at the national level in the first three cycles were 88.7%, 82.6% and 89.7%, respectively.

The CCHS includes a sample of about 130 000 respondents and was designed to provide reliable estimates at the local health region level.[24] For this study, we used cycles of CCHS data where the HUI was available for all Canadian provinces: 2000/01, 2003, 2005 and 2009/10. The household-level response rates in those cycles varied from 72.3% (2009/10) to 84.7% (2000/01). Data for the CCHS 2003 and 2005 were collected over a one-year period.

The target population of NPHS included respondents of all ages, but only those who were aged 12 years and over were targeted in the CCHS. As such, for the group under age 12 years, we substituted HUI values of 0.99 on the assumption that not all individuals in those age groups have perfect health. We chose the HUI value of 0.99 because the health-related quality of life is expected to be very high among children under age 12 years. Both surveys excluded persons living on Indian reserves and Crown lands, residents of health institutions, full-time members of the Canadian Forces living on Canadian Forces bases, and residents of some remote areas in Ontario and Quebec. Our analysis excluded the three Canadian territories, since data were not available in all of our selected cycles.

We used data from Statistics Canada[25] to estimate mortality rates by province, sex and five-year age group. The three-year moving average method was used to obtain robust estimates, which is particularly important for calculating values for provinces with a small population. Three years of data are needed to provide large enough numbers to ensure that the mortality rates, which are used to estimate LE and HALE, are sufficiently robust. The three-year periods we used corresponded to the timing of the seven survey cycles used to calculate HALE: 1993 to 1995, 1995 to 1997, 1997 to 1999, 2000 to 2002, 2002 to 2004, 2004 to 2006 and 2009 to 2011.

We measured health-related quality of life (HRQL) with the Health Utilities Index (HUI) Mark 3 instrument, which is available in both surveys.[24,26] HUI is a multi-attribute utility measure that defines health states according to eight attributes

(vision, hearing, speech, ambulation, dexterity, emotion, cognition and pain), with five or six levels of functioning ranging from normal to severely limited functioning for each. The overall scores of the HUI range from −0.36 (the worst possible health state, e.g. a state in which death might be preferable) through 0.0 (death) to 1.0 (the best possible health state). Differences of 0.03 or more in overall HUI scores are considered to be clinically important.[26]

We used the Chiang method,[27] combined with the Hsieh method,[28] to generate period life tables by sex using 19 standard age groups (< 1, 1–4, 5 – 9, ... 80–85 and 85+ years). The Chiang method is an established method widely used internationally to build abridged life tables. Age-specific mortality rates are used within the life table to calculate the probability of dying at each age interval, which are then applied to a hypothetical population cohort. The Hsieh method, based on the Gompertz function, was used to provide an accurate estimate of LE for the last open-ended 85+ age interval. We applied the modified Sullivan method[7] for the HALE calculation. According to this method, the "life-years lived" in each age interval was adjusted by the HUI. HALE variance was calculated following Mathers' method,[9] which takes into account the variance of the probability of dying generated by the life-table method and the variance of the HUI.

To analyze the trend in health expectancy, and more specifically the morbidity scenarios, we calculated the annual percent rate of change in HALE and the "proportion of life spent in an unhealthy state," represented by (LE − HALE)/LE, by fitting a log-linear regression model. It is necessary to assess the difference between HALE and LE, proportional to LE since HALE is essentially a measure of LE weighted according to health-related quality of life and is thus highly correlated with LE.

As an additional measure of the contribution of HRQL to HALE trends in Canada, we decomposed the differences in HALE between the baseline reporting period (1994/95) and all subsequent periods into mortality and morbidity (HRQL) components using the Arriaga method[29] adopted for the Sullivan method.[30]

Results

Mean HUI values fluctuated over the course of our study period for the Canadian population aged 12 years and older (Figure 1). Both females and males experienced a statistically significant average increase in the HUI value of just under 0.01 during the study period: from 0.862 in 1994/95 to 0.871 in 2009/10 for females ($p < .01$) and from 0.879 in 1994/95 to 0.886 in 2009/10 for males ($p < .05$). However, while both females and males experienced a clinically important increase in HRQL from 1994/95 to 1996/98 (i.e. an increase in HUI of 0.03 or greater), the overall HRQL increase for the entire study period was not clinically important for either sex.

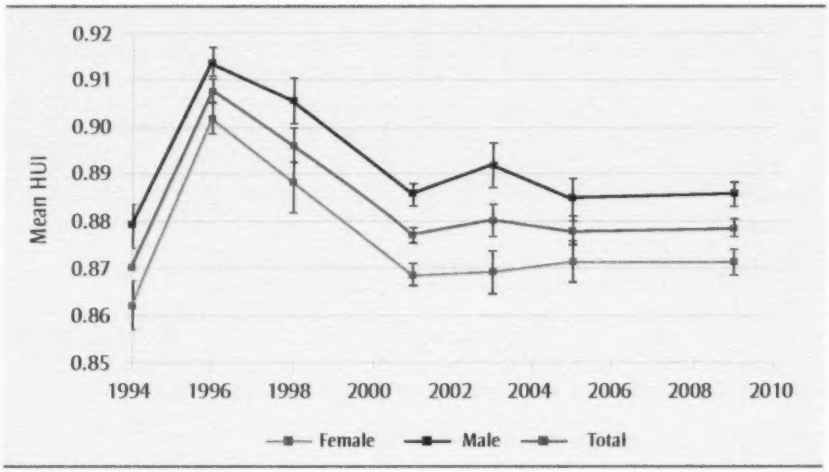
HALE increased consistently over the reporting period for both Canadian females and males (Tables 1A, 1B and 1C). For females, HALE increased by 3.3 years at birth, 3.1 years at age 20 and 2.0 years at age 65. However, only females at age 20 and 65 years experienced significant annual average increases in HALE: 0.2% ($p < .05$) and 0.7% ($p < .001$) respectively. For males, HALE increases from 1994/95 to 2009/10 were 4.3 years at birth, 4.0 years at age 20 and 2.6 years at age 65. This corresponds to significant annual average increases in HALE at each of these age groups: 0.3% at birth, 0.4% at age 20 and 1.2% at age 65 ($p < .001$ for each).

The proportion of life spent in an unhealthy state [(LE − HALE)/LE] fluctuated over the course of our study period. For Canadian females and males at birth this proportion decreased from 1994/95 (females 14%, males 12%) to 1996/97 (females 11%, males 9%), which indicated compression of morbidity. It then increased in the remaining period up to 2009/10 (females 13%, males 11%) (Table 1A), which indicated expansion of morbidity. For the overall study period, the proportion of life spent in an unhealthy state did not significantly change (Tables 1A, 1B, 1C), indicating neither compression nor expansion of morbidity. This same pattern was observed in females and males at age 20 and females at age 65 (Tables 1B, 1C). Males at age 65 experienced a non-significant decrease in annual average change of proportion of life spent in an unhealthy state.

Decomposition of the differences in HALE at birth for each reporting period compared to the baseline values of 1994/95 demonstrated a continual increase in HALE gains associated with the mortality component (Table 2). However, the gains attributed to HRQL (i.e. the morbidity component) fluctuated throughout the study period, also suggesting no clear trend in expansion or compression of morbidity. These trends were similar for both females and males.

HALE trends in the provinces largely mirrored those in the Canadian population as

FIGURE 1
Mean Health Utilities Index values, population aged 12 years and older, by sex and reporting period, Canada, 1994 to 2010



Abbreviation: HUI, Health Utilities Index.

TABLE 1A
Life expectancy, health-adjusted life expectancy and proportion of life spent in an unhealthy state at birth, by sex and reporting period, Canada, 1994 to 2010

	1994/95	1996/97	1998/99	2000/01	2003	2005	2009/10	Average annual change (%)
Female								
LE	81.3	81.5	81.8	82.5	82.8	83.2	84.1	
HALE	70.0	72.9	72.1	71.5	71.7	72.3	73.3	0.2
HALE (95% CI)	69.5–70.4	72.5–73.2	71.7–72.5	71.3–71.7	71.3–72.1	71.9–72.6	73.1–73.5	
(LE–HALE)/LE (%)	14	11	12	13	13	13	13	0.4
Male								
LE	75.2	75.7	76.2	77.2	77.7	78.3	79.6	
HALE	66.4	69.0	68.9	68.5	69.5	69.3	70.7	0.3*
HALE (95% CI)	66.0–66.8	68.7–69.2	68.6–69.3	68.3–68.7	69.1–69.8	69.0–69.7	70.5–70.9	
(LE–HALE)/LE (%)	12	9	10	11	11	11	11	0.6

Abbreviations: CI, confidence interval; HALE, health-adjusted life expectancy; LE, life expectancy; (LE – HALE)/LE, the proportion of life spent in an unhealthy state.

* $p < .05$.

a whole (Tables 3A, 3B). However, there were provincial differences. From 1994/95 to 2009/10, significant annual average increases in HALE at birth (both sexes combined) were observed in British Columbia and Quebec only. At age 65, HALE increased significantly in all provinces except NL and Nova Scotia.

In terms of proportion of life spent in an unhealthy state, at birth and at age 65, similar to the Canadian trend, most provinces did not experience significant changes over the study period. The exceptions were NL and PEI, each of which had a significant increase at birth, suggesting an expansion of morbidity. When results were stratified by sex (not shown), the significant increase in proportion of life spent in an unhealthy state at birth persisted only for males in NL and PEI. At age 65, males in NL experienced a significant increase in the proportion, while Manitoban males exhibited a significant decrease.

Discussion

Our study provides a comprehensive look into the public health scenarios of compression or expansion of morbidity in Canada by tracking trends in life expectancy and health-adjusted life expectancy from 1994 to 2010. Our results demonstrate that both LE and HALE increased for females and males during the study period. While the proportion of life spent in an unhealthy state fluctuated, the

TABLE 1B
Life expectancy, health-adjusted life expectancy and proportion of life spent in an unhealthy state at age 20, by sex and reporting period, Canada, 1994 to 2010

	1994/95	1996/97	1998/99	2000/01	2003	2005	2009/10	Average annual change (%)
Female								
LE	61.7	61.8	62.1	62.8	63.0	63.4	64.4	
HALE	51.4	54.0	53.1	52.7	53.1	53.5	54.5	0.2*
HALE (95% CI)	51.0–51.9	53.7–54.3	52.7–53.5	52.5–52.9	52.7–53.5	53.1–53.9	54.3–54.8	
(LE–HALE)/LE (%)	17	13	15	16	16	16	15	0.3
Male								
LE	55.7	56.2	56.7	57.7	58.1	58.7	59.9	
HALE	48.0	50.1	50.1	49.8	50.9	50.8	52.0	0.4*
HALE (95% CI)	47.6–48.3	49.8–50.3	49.7–50.4	49.6–50.0	50.5–51.2	50.4–51.2	51.8–52.2	
(LE–HALE)/LE (%)	14	11	12	14	12	13	13	0.5

Abbreviations: CI, confidence interval; HALE, health-adjusted life expectancy; LE, life expectancy; (LE – HALE)/LE, the proportion of life spent in an unhealthy state.

* $p < .05$.

TABLE 1C
Life expectancy, health-adjusted life expectancy and proportion of life spent in an unhealthy state at age 65, by sex and reporting period, Canada, 1994 to 2010

	1994/95	1996/97	1998/99	2000/01	2003	2005	2009/10	Average annual change (%)
Female								
LE	19.9	19.9	20.2	20.7	20.9	21.3	22.1	
HALE	14.8	15.6	15.3	15.4	15.7	16.0	16.8	0.7[a]
HALE (95% CI)	14.4–15.1	15.3–15.9	15.0–15.7	15.2–15.6	15.4–16.1	15.6–16.3	16.7–17.0	
(LE–HALE)/LE (%)	26	22	24	26	25	25	24	0.05
Male								
LE	15.8	15.9	16.2	17.0	17.4	17.9	18.9	
HALE	12.3	12.8	12.8	13.1	14.0	14.2	14.9	1.2[a]
HALE (95% CI)	12.0–12.6	12.6–13.1	12.5–13.1	13.0–13.3	13.7–14.3	13.9–14.5	14.7–15.1	
(LE–HALE)/LE (%)	22	19	21	23	19	21	21	−0.1

Abbreviations: CI, confidence interval; HALE, health-adjusted life expectancy; LE, life expectancy; (LE – HALE)/LE, the proportion of life spent in an unhealthy state.

[a] $p < .05$.

statistically non-significant average annual increase in this proportion observed over the entire study period appeared to indicate that there was no clear overall trend in compression or expansion of morbidity from 1994 to 2010 in Canada. This lack of a clear trend can also be seen in the decomposition of HALE differences, which did not show any consistent trends in gains or losses associated with the morbidity component (HRQL).

The trend results for the provinces indicate that, while health expectancy values generally reflect a certain amount of stability between 1994/95 and 2009/10, there may be some expansion of morbidity occurring among males in NL and PEI. Removing data for 1996/97, where a clinically important increase in HUI was observed, did not change the results. Further study is needed to assess which determinants of health may be influencing the changes observed in NL and PEI.

A previous study of morbidity trends in the Canadian adult population found that disability-free life expectancy as a proportion of life expectancy had decreased, suggesting an expansion of morbidity between 1994/95 and 2007.[19] However, that study only used two reporting periods and as such does not allow meaningful interpretation of annual changes occurring within this period. Our findings are similar to a study of disability trends in OECD countries,[31] which found that disability prevalence, as measured by limitations in activities of daily living, remained stable in the Canadian population aged 65 years and older for the period of 1996 to 2003. With respect to the provincial results, the

TABLE 2
Contribution of mortality and morbidity components to differences in HALE[a] at birth for each reporting period (compared to baseline period), by sex, Canada, 1994 to 2010

Gains[b]	1994/95	1996/97	1998/99	2000/01	2003	2005	2009/10
Female							
HALE gains ($HALE_t - HALE_n$)	0 (REF)	2.9	2.1	1.5	1.7	2.3	3.3
Mortality gain component	0 (REF)	0.1	0.4	0.8	1.0	1.3	2.0
Morbidity (HRQL) gain component	0 (REF)	2.7	1.7	0.7	0.7	0.9	1.3
Male							
HALE gains ($HALE_t - HALE_n$)	0 (REF)	2.5	2.5	2.1	3.1	2.9	4.3
Mortality gain component	0 (REF)	0.4	0.8	1.6	2.0	2.4	3.4
Morbidity (HRQL) gain component	0 (REF)	2.1	1.7	0.5	1.1	0.6	0.9

Abbreviations: $HALE_t$, health-adjusted life expectancy for given reporting period; $HALE_n$, health-adjusted life expectancy for 1994/95 baseline period; HRQL, health-related quality of life; REF, reference group.

[a] The sum of mortality and morbidity gain components may not exactly match the HALE gain due to rounding.

[b] Gains in this table are expressed in years.

TABLE 3A
Average annual change in health-adjusted life expectancy and in proportion of life spent in an unhealthy state at birth, both sexes combined, by province, Canada, 1994 to 2010

	1994/95	1996/97	1998/99	2000/01	2003	2005	2009/10	Average annual change (%)
Alberta								
HALE	68.3	70.8	70.7	69.1	70.3	70.3	71.3	+0.1
(LE−HALE)/LE (%)	13	10	11	14	13	13	13	+0.7
British Columbia								
HALE	68.5	70.9	70.6	70.1	70.6	70.9	72.8	+0.3[a]
(LE−HALE)/LE (%)	13	10	11	13	13	13	12	+0.2
Manitoba								
HALE	68.0	70.4	68.8	69.3	69.7	70.2	70.0	+0.1
(LE−HALE)/LE (%)	13	10	12	12	12	12	13	+0.4
New Brunswick								
HALE	67.0	69.7	70.2	69.3	69.2	69.6	70.2	+0.2
(LE−HALE)/LE (%)	14	11	10	13	13	13	13	+0.6
Newfoundland and Labrador								
HALE	68.5	71.0	71.5	69.1	68.5	68.2	69.2	−0.1
(LE−HALE)/LE (%)	11	8	8	11	12	13	13	+2.5[a]
Nova Scotia								
HALE	65.8	68.9	69.3	68.2	68.9	68.5	69.2	+0.2
(LE−HALE)/LE (%)	15	11	12	14	13	14	14	+0.3
Ontario								
HALE	67.7	71.4	70.7	69.5	70.4	71.0	71.7	+0.2
(LE−HALE)/LE (%)	14	10	11	13	13	12	13	+0.7
Prince Edward Island								
HALE	69.0	70.0	70.7	69.5	70.2	69.5	71.0	+0.1
(LE−HALE)/LE (%)	11	10	10	12	12	13	12	+1.1[a]
Quebec								
HALE	69.1	71.2	71.1	71.3	71.7	71.6	73.6	+0.3[a]
(LE−HALE)/LE (%)	11	9	10	10	10	11	10	+0.4
Saskatchewan								
HALE	68.7	70.3	70.8	69.3	70.5	69.7	70.1	+0.0
(LE−HALE)/LE (%)	13	11	10	13	11	13	12	+0.4

Abbreviations: HALE, health-adjusted life expectancy; (LE − HALE)/LE, the proportion of life spent in an unhealthy state.

[a] $p < .05$.

study from Quebec[22] covered a period (1986–1998) most of which occurred before our study (1994–2010), so comparisons are difficult. That study suggested an expansion of morbidity, although once again, the use of only two reporting periods prevents meaningful interpretation of trends.

Our findings provide some support to the hypothesis of Robine and Michel,[32] who predicted that economically developed countries would experience a pattern of initial expansion of morbidity due to increased survival rates with disabling conditions, followed by compression as improvements were made in controlling chronic diseases and improving health behaviours in new cohorts of older people. It is possible that Canada has progressed from the initial expansion of morbidity phase in the 1980s and 1990s into a period of stasis due to improvements in chronic disease prevention and health promotion. An assessment of healthy life expectancy trends in Canada during this earlier period[33] suggests that there was a period of expansion of morbidity between 1986 and 1991. However, these trends will need to be followed over time to confirm this hypothesis. Robine and Michel also hypothesize a final stage in this "disability transition," in which

TABLE 3B
Average annual change in health-adjusted life expectancy and in proportion of life spent in an unhealthy state at age 65, both sexes combined, by province, Canada, 1994 to 2010

	1994/95	1996/97	1998/99	2000/01	2003	2005	2009/10	Average annual change (%)
Alberta								
HALE	13.5	14.5	14.3	14.1	15.4	14.8	15.7	+0.8*
(LE−HALE)/LE (%)	26	22	24	27	21	26	24	−0.1
British Columbia								
HALE	14.6	14.3	14.4	14.6	15.1	15.1	16.5	+0.8*
(LE−HALE)/LE (%)	22	24	25	26	24	25	22	+0.1
Manitoba								
HALE	12.9	14.3	13.8	14.2	14.2	15.2	15.3	+0.9*
(LE−HALE)/LE (%)	29	21	24	25	25	21	23	−0.9
New Brunswick								
HALE	13.8	13.7	14.1	14.1	14.3	14.7	15.3	+0.7*
(LE−HALE)/LE (%)	22	23	21	23	23	23	23	+0.4
Newfoundland and Labrador								
HALE	13.2	13.8	13.6	13.1	13.7	13.2	14.4	+0.3
(LE−HALE)/LE (%)	21	17	18	24	21	24	22	+1.2
Nova Scotia								
HALE	13.0	14.2	13.9	13.4	13.7	14.1	14.4	+0.4
(LE−HALE)/LE (%)	25	19	22	26	25	24	25	+1.0
Ontario								
HALE	13.3	14.4	14.2	14.0	14.7	15.4	15.8	+0.9*
(LE−HALE)/LE (%)	26	20	22	26	24	22	24	+0.1
Prince Edward Island								
HALE	13.6	14.1	14.1	14.3	14.5	14.6	15.1	+0.6*
(LE−HALE)/LE (%)	23	21	22	21	21	25	23	+0.6
Quebec								
HALE	13.7	14.2	14.1	14.9	15.1	15.2	16.6	+1.2*
(LE−HALE)/LE (%)	22	20	22	20	20	22	19	−0.5
Saskatchewan								
HALE	14.4	14.4	14.6	14.4	15.2	14.9	15.4	+0.4*
(LE−HALE)/LE (%)	24	23	22	25	22	24	23	−0.2

Abbreviations: HALE, health-adjusted life expectancy; (LE − HALE)/LE, the proportion of life spent in an unhealthy state.

*$p < .05$.

morbidity expands again due to the emergence of very old and frail populations.[32] This would also need to be monitored on an ongoing basis in the Canadian population.

Strengths and limitations

The main strength of our study was the ability to detect changes in healthy life expectancy at the population level over a reasonably long period of time with multiple reporting points. Our study used seven reporting secular time points representing 15 years of observation taken from two major national health studies that used virtually the same sampling frame of the Canadian household population and the same measure of health-related quality of life. The combination of length of reporting period and frequency of reporting points in our study exceeded that of all other studies we identified in the literature.

Our study had several limitations. It was beyond the scope of our study to assess the impact of socioeconomic and behavioural factors on healthy life expectancy trends. For instance, it is possible that provinces may experience a decline in healthy life expectancy due to loss of healthy adults migrating to other provinces

for work.[34] Further studies are needed to test this hypothesis, as well as other potential socioeconomic factors. Unlike most studies assessing trends in health expectancy, we did not use a measure of limitations in activities of daily living. This limits our ability to make comparisons to results from studies conducted for other nations. However, a validation study of several measures of disability[35] found the HUI to correlate well with a measure of activity and participation limitations, suggesting that trends measured with HUI should reflect those found using these other measures.

It should also be noted that it was beyond the scope of our study to assess a third proposed morbidity scenario called "dynamic equilibrium."[36] This scenario hypothesizes a state of equilibrium where life expectancy increases, while a longer proportion of life spent living with chronic diseases is counteracted by a decrease in the severity of these diseases. Future studies of Canadian morbidity trends should incorporate more explicit measures of severity of disability in order to assess whether the Canadian population is experiencing this scenario.

With respect to the data sources used in our study, neither the NPHS nor the CCHS cover the Canadian population living in institutions, including those associated with long-term care. Additionally, the CCHS only covers the population aged 12 years and older, which obliged us to use assumed HUI values for the population under age 12 years. It is thus possible that the health expectancy values for these excluded populations are different from those of the household population. There is a theoretical possibility of this affecting the direction of the trends over the reporting period, since there is a trend towards facilitating the elderly population to remain at home, which may contribute to greater proportions of incapacitated individuals remaining in the general population.

Finally, the second (1996/97) and third (1998/99) cycles of the NPHS are constituted of both a cross-sectional sample of the Canadian household population and panel members of the longitudinal cohort portion of this same study. As such, there is a possibility that health expectancy results from these two cycles differ from the other purely cross-sectional survey cycles. This is because surviving panel members might have contributed to a "healthy volunteer" effect whereby their ability to survive to, and ability to participate in, the subsequent rounds of follow-up were due to the fact that they were healthier than the general population.[37] Indeed, we observed elevated average HUI values for these two cycles. We conducted a sensitivity analysis by removing the 1996/97 cycle data from our calculations: these results confirmed the statistically significant expansion of morbidity at birth for males living in NL and PEI, and relative stability for the total Canadian population.

Conclusion

Our study analyzed the trends in morbidity as compared to the trends in life expectancy at birth, at age 20 years and at age 65 years. In the context of population aging, it is important to monitor these two trends, because expansions and compressions of morbidity have very different impacts on future trends in health care expenditures. The lack of comparable data has been an issue in the past; this study provides valuable information to identify the direction Canada has taken over a 15-year period. Additional results by province provide information that has been lacking up to now.

Contrary to other industrialized countries where compression or expansion of morbidity has been observed in studies for the last 30 to 40 years, the Canadian population as a whole appeared to be experiencing a period of relative stability in health expectancy from 1994 to 2010. However, there appeared to be an expansion of morbidity in NL and in PEI, particularly among males. Continued surveillance of health expectancy trends will be necessary to detect whether Canada makes further transitions towards increasing morbidity. Further study should also be undertaken to confirm these observations and to better understand what is driving the expansion of morbidity in NL and in PEI.

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Data sharing statement

Data used in this study were accessed through sharing agreements with Statistics Canada and the Canadian provinces and territories. Other researchers can access Statistics Canada data through the Data Liberation Initiative of Statistics Canada.

Conflicts of interest

No funding was provided for this study. The authors have no competing interests to declare.

Authors' contributions

Colin Steensma contributed to the study design, interpretation of the data, drafting of the article and critical review of the article. Lidia Loukine contributed to the study design, statistical analyses, drafting of the article and critical review of the article. Bernard Choi contributed to the study concept and design, drafting of the article and critical review of the article.

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The association of household food security, household characteristics and school environment with obesity status among off-reserve First Nations and Métis children and youth in Canada: results from the 2012 Aboriginal Peoples Survey

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Abstract

Introduction: Indigenous children are twice as likely to be classified as obese and three times as likely to experience household food insecurity when compared with non-Indigenous Canadian children. The purpose of this study was to explore the relationship between food insecurity and weight status among Métis and off-reserve First Nations children and youth across Canada.

Methods: We obtained data on children and youth aged 6 to 17 years (n = 6900) from the 2012 Aboriginal Peoples Survey. We tested bivariate relationships using Pearson chi-square tests and used nested binary logistic regressions to examine the food insecurity – weight status relationship, after controlling for geography, household and school characteristics and cultural factors.

Results: Approximately 22% of Métis and First Nations children and youth were overweight, and 15% were classified as obese. Over 80% of the sample was reported as food secure, 9% experienced low food security and 7% were severely food insecure. Off-reserve Indigenous children and youth from households with very low food security were at higher risk of overweight or obese status; however, this excess risk was not independent of household socioeconomic status, and was reduced by controlling for household income, adjusted for household size. Negative school environment was also a significant predictor of obesity risk, independent of demographic, household and geographic factors.

Conclusion: Both food insecurity and obesity were prevalent among the Indigenous groups studied, and our results suggest that a large proportion of children and youth who are food insecure are also overweight or obese. This study reinforces the importance of including social determinants of health, such as income, school environment and geography, in programs or policies targeting child obesity.

Keywords: *child obesity, food insecurity, Indigenous peoples, First Nations, Métis, school environment*

Highlights

- Off-reserve Indigenous children and youth from households with very low food security were at higher risk of being overweight or obese.
- Children and youth whose school environments were rated the most negative (e.g. exposure to racism, bullying and drugs) were the most likely to be overweight or obese relative to those who rated their school environments the least negatively.
- There was no difference in weight status between Indigenous children and youth living in rural, small, medium or large cities.

Introduction

Indigenous children in Canada (including First Nations, Métis and Inuit) are at a disproportionately higher risk for overweight and obesity compared to their non-Aboriginal Canadian counterparts.[1,2] Defined as the accumulation of excess body fat, obesity is associated with poor health outcomes including compromised immune function, mental health disorders, type 2 diabetes, cardiovascular disease, sleep apnea and decreased quality of life.[3-7]

According to the 2009-2011 Canadian Health Measures Survey, approximately one-third of Canadian children and youth between 5 and 17 years of age are classified as overweight (body mass index [BMI] ≥25kg/m^2– < 30kg/m^2) or obese (BMI ≥30kg/m^2), with Indigenous children and youth being twice as likely to be classified as obese in comparison.[4] Corroborating this pattern, the Public Health Agency of Canada reports that 20% of First Nations children living outside of First Nations reserves and 16.9% of Métis children have a BMI ≥ 30, compared to 11.7% of non-Indigenous Canadian children.[2,4]

While the etiology of obesity is multifactorial and complex, a social determinants of health framework provides a starting point for unpacking the distal* causes of

* Based on social and ecological frameworks of health, proximal determinants include individual-level (e.g. behaviour, early life events) and interpersonal factors (e.g. family practices, physical environment). Distal factors (e.g. household characteristics, community, built environment, society, historical factors) are located further in a causal chain or ecological framework and impact individual health through proximal or intermediary factors.

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child obesity, as well as identifying targets for prevention and treatment.[8,9] However, the health disparities experienced by Indigenous peoples highlight the fact that these social determinants are experienced differently by Indigenous populations and must be explored alongside more culturally relevant factors. Several Indigenous-specific social determinants of health models have been developed as a result, including an ecological model by Willows et al.[8] that includes causal factors related to households, schools, communities and the macrosocial context. Greenwood and de Leeuw[9] use a web diagram to demonstrate that there are multiple interrelated relevant social determinants of Aboriginal peoples' health operating at various socio-ecological levels.

One factor noted in these models that has been gaining increased attention in obesity research is the importance of food security for weight status. Food insecurity is defined as a situation in which availability or access to nutritionally adequate and culturally acceptable food is limited or uncertain.[10,11] While the relationship between food insecurity and obesity may seem paradoxical, research is increasingly linking the two, as food insecurity results in a lack of affordable nutritious food choices, which then may result in obesity.[12-16]

Adults and children have distinct experiences of food insecurity, as children are more vulnerable to resultant behavioural problems, such as decreased school attendance and performance, and poorer overall health and nutrition, despite parents' efforts to minimize food insecurity's impact.[13,17,18] A possible relationship between food insecurity and obesity may be especially relevant for Indigenous children, as Indigenous households are three times more likely to experience food insecurity than non-Indigenous Canadians.[19,20] The 2007/2008 Canadian Community Health Survey found that 20.9% of Indigenous households were food insecure, with 8.4% experiencing "severe" food insecurity.[20] In comparison, 7.2% of non-Indigenous households were food insecure and 2.5% experienced severe food insecurity.[20] Much of this discrepancy can be explained by the higher prevalence of sociodemographic risk factors in Indigenous households (e.g. household crowding, lower household income),[19] many of which have also found to be related to obesity.[21]

Previous qualitative research with off-reserve Métis and First Nations parents found that food insecurity was perceived by community members to be an important cause of obesity in their communities.[22] In those interviews, food insecurity was thought to be not only a result of low income, but also the high price of fresh food in some locations and a lack of transportation. For some, the loss of traditional food and knowledge about its preparation was also important, leading to poorer diets.[22] However, the association between food insecurity and obesity in Indigenous children has not been quantitatively examined. Moreover, it is important to consider this relationship in the context of other potentially important effects, including household characteristics, school-level factors, geography and cultural factors. In this paper, we make use of the 2012 Aboriginal Peoples Survey (APS)[23] to examine the association between household food security status and obesity among off-reserve First Nations and Métis children and youth in Canada, independent of other household, school, geographic and cultural factors.

Methods

Data and participants

The 2012 APS was a postcensal, national survey of the population aged 6 years and older identified in the 2011 National Household Survey,[24] and living outside of First Nations reserve communities as well as select Indigenous communities in the North.[21,23]

This study focussed on First Nations and Métis children and youth aged 6 to 17 years. Inuit children and youth were excluded, as the geography-driven factors affecting their food security status, as well as their unique BMI profiles and body fat distribution, require independent investigation.[25,26] After excluding the Inuit population and adults aged 18 years and over, the final sample included 6900 individuals. Questions for children aged 6 to 14 years were answered by the "person most knowledgeable" (PMK) about the child, generally a parent or guardian. Youth aged 15 to 17 years were interviewed directly. Details about the sampling, data collection and weighting are available in the APS concepts and methods guide.[23]

Main variables

Obesity status

The dependent variable was weight-status based on BMI categorization using Cole's BMI cut-offs.[27] BMI was calculated using PMK-reported height and weight of children. The APS asked, "How tall is [your child] without shoes on?" and "How much does [your child] weigh?" in order to calculate BMI.[28] Weight status categories included normal, overweight and obese.

Food insecurity

The 2012 APS measured household food insecurity over the past 12 months using a series of six statements to which the PMK responded, "often true," "sometimes true" or "never true." The statements captured whether households were able to afford balanced meals, if meals had been downsized or skipped because there was not enough money for food, the frequency of these events, and how often household members experienced hunger. These responses were used by Statistics Canada to categorize households into four levels of food security: high, marginal, low and very low.[28] In the analyses, "highly secure" and "marginally secure" were combined into one category.

Covariates

In addition to household food insecurity, covariates included demographic, household, school, geographic and cultural variables previously identified as having potential relationships with food insecurity or obesity.

The demographic variables included were Indigenous identity group (First Nations or Métis), age (6 – 11 or 12 – 17 years) and gender (male, female). Household socioeconomic characteristics included annual household income and mother's educational attainment. Household income was divided by the number of household members to provide a "per capita" household measure, which was included as quartiles (less than $9510; $9510 – $16 680; $16 690 – $27 260; and $27 280 and above). Other household characteristics included family structure (two-parent, lone-parent or other), as well as household crowding, which was measured based on the number of people per room.

The APS included questions about the school environment. Respondents were asked to indicate their level of agreement using a four-point scale (strongly disagree, disagree, agree, strongly agree) with eight statements. Aspects of a positive school environment were captured by asking:

1) "Overall, respondent feels/felt safe at school"; 2) "Overall, respondent is/was happy at school"; 3) "Most children enjoy/enjoyed being at school"; and 4) "The school provides/provided many opportunities to be involved in school activities." Negative aspects of the school environment were captured by agreement with 1) "Racism is/was a problem at school"; 2) "Bullying is/was a problem at school"; 3) "The presence of alcohol is/was a problem at school"; 4) "The presence of drugs is/was a problem at school"; and 5) "Violence is/was a problem at school." For each child, responses to the positive and negative environment questions were averaged, so that higher scores indicate more positive or more negative environments.

Regional and urban/rural geography were also part of the analysis, as research strongly suggests the importance of broader environmental factors.

Lastly, the cultural variables, "exposure to Indigenous language" and "family members' attendance of residential schools," were also included to capture their potential influence on children's weight status. It has been suggested that cultural characteristics such as language retention are important for Indigenous peoples' health in general, and previous research using the 2006 APS has found that parental residential school attendance was predictive of obesity among Métis children.[9,22] Children who were reported to be exposed to an Aboriginal language at home or outside the home were coded as "exposed." The APS asked whether the child's PMK (usually a parent) or the PMK's mother or father (the child's grandparent) had attended Indian residential or industrial schools. Those who did not respond to these questions (17%) were retained as a separate category called "not stated."

Statistical analyses

We used Pearson chi-square tests to assess bivariate associations between the independent variables and obesity. Thereafter we used a binary multivariate logistic regression to test the likelihood of children and youth having BMI in the "normal" range, versus being "overweight" or "obese," conditional on the independent variables that we found to have significant bivariate associations with overweight and obesity. A total of five nested models were fitted, including different groups of predictor variables. We performed our statistical analysis using SAS software version 9.4.[29] We used bootstrap weights provided by Statistics Canada and balanced repeated re-estimation (BRR) to adjust variance estimates for the survey's complex sampling design.

Results

Table 1 provides demographic, socioeconomic and other characteristics of the sample. Approximately 22% of First Nations and Métis children and youth aged 6 to 17 years were overweight, and 14.9% were classified as obese. While 83.8% of the sample reported as food secure, 9.4%

TABLE 1
Sample characteristics by body mass index, First Nations and Métis youth aged 6 to 17 years, Canada, 2012

Variable	N	Normal weight (%)	Overweight[a] (%)	Obese[b] (%)	*p*-value
Household food security status					
Marginal or high food security	5780	63.6	22.1	14.3	< .001
Low food security	650	58.5	24.6	16.9	
Very low food security	470	53.1	27.7	19.2	
Regional geography					
Atlantic	460	63.0	19.6	17.4	< .001
Quebec	400	62.5	25.0	12.5	
Ontario	1730	61.3	23.7	15.0	
Prairies	2970	60.8	23.0	16.2	
British Columbia	1260	68.3	20.6	11.1	
Territories	70	71.4	14.3	14.3	
Urban/rural geography					
Rural	1590	65.6	18.8	15.6	< .001
Small population centre	1640	57.5	27.3	15.2	
Medium population centre	890	61.1	22.2	16.7	
Large population centre	2780	64.3	21.4	14.3	
Age group					
6–11 years	3110	52.7	24.1	23.2	< .001
12–17 years	3790	70.4	21.4	8.2	
Gender					
Male	3530	59.7	24.1	16.2	< .001
Female	3370	65.5	21.1	13.4	

Continued on the following page

TABLE 1 (continued)
Sample characteristics by body mass index, First Nations and Métis youth aged 6 to 17 years, Canada, 2012

Variable	N	Normal weight (%)	Overweight[a] (%)	Obese[b] (%)	*p*-value
Indigenous identity					
First Nations	3930	59.8	23.7	16.5	< .001
Métis	2970	65.9	21.6	12.5	
Mother's educational attainment					
Less than secondary school graduation	1130	59.3	23.9	16.8	.002
Secondary school diploma or equivalent	1300	59.9	23.9	16.2	
Some post-secondary education	720	61.1	22.2	16.7	
Post-secondary certificate, diploma or degree	3750	64.6	22.1	13.3	
Annual household income per capita					
1st quartile	1890	55.6	25.9	18.5	< .001
2nd quartile	1660	60.8	21.7	17.5	
3rd quartile	1690	65.7	22.5	11.8	
4th quartile	1660	68.1	21.1	10.8	
Family structure					
Two-parent family	4270	64.4	22.5	13.1	< .001
Lone-parent family	2350	58.7	23.0	18.3	
Other	280	64.3	25.0	10.7	
Household crowding					
One or fewer people per room	6330	62.8	22.8	14.4	.007
More than one person per room	570	59.6	21.1	19.3	
Positive school environment index					
1st quartile (1.00–2.75)	1370	65.0	21.9	13.1	< .001
2nd quartile (3.00–3.00)	1980	60.1	25.8	14.1	
3rd quartile (3.25–3.67)	1640	65.2	22.0	12.8	
4th quartile (3.75–4.00)	1900	60.5	21.1	18.4	
Negative school environment index					
1st quartile (1.00–1.60)	1850	54.8	21.1	24.1	.031
2nd quartile (1.75–2.00)	2080	61.7	22.5	15.8	
3rd quartile (2.20–2.25)	1040	59.6	24.0	16.4	
4th quartile (2.40–4.00)	1930	63.2	23.8	13.0	
Exposure to Indigenous language					
No	3420	65.7	22.0	12.3	< .001
Yes	3480	59.5	23.3	17.2	
Family member attended residential schools					
No	2930	63.8	22.2	14.0	< .001
Yes	2780	59.7	23.4	16.9	
Not stated	1180	66.1	22.0	11.9	

Source: Data from the 2012 Aboriginal Peoples Survey.

Notes: Sample numbers according to BMI: normal weight: n = 4310; overweight: n = 1560; obese: n = 1030. Frequency counts for all variables were rounded to the nearest 10.

[a] Having a BMI ≥ 25kg/m^2 but < 30kg/m^2

[b] Having a BMI ≥ 30kg/m^2

experienced low food security and 6.8% were severely food insecure.

There were significant differences in the percentage of children and youth classified as normal, overweight and obese for all of the covariates examined (Table 1). At the individual level, among those who experienced very low food security, 27.7% were overweight and 19.2% were obese. Age was a critical factor for weight status, as 47.3% of Aboriginal children between the ages of 6 and 11 years were either overweight or obese compared to 30% of youth aged 12 to 17 years. A larger proportion of males fell into the overweight or obese classification (40.3%) compared to females (34.5%). Indigenous identity also had a marginal impact on the likelihood of overweight or obese weight status, as 40% of First Nations children fell into these weight categories, compared with 34% of Métis children. Children and youth who were exposed to an Aboriginal language were more likely to be overweight or obese (40.5%) compared to those who had no exposure (34.5%).

The family-level variables also tell an interesting story. The proportion of overweight or obese children does not largely differ based on mother's educational attainment; 41% of children whose mothers had less than secondary school graduation were overweight or obese, and approximately 35% of children whose mothers obtained a post-secondary certificate, diploma or degree fell into these weight categories. Almost half (44%) of children from the lowest income quartile were overweight or obese. The proportion of children from two-parent families classified as overweight or obese (35.6%) was almost six percentage points less than children from lone-parent families (41.3%), but similar to the proportion of overweight and obesity among children who lived in "other" family structures (i.e. children or youth living alone, with a relative or non-relative) (35.7%). Of children and youth living in households where there was more than one person per room, 40.0% were classified as overweight or obese compared to 37.2% of children living in households with one or fewer people per room. While 17% of the sample did not respond to the question about a family member attending residential schools, children whose family members had attended residential schools had a higher proportion of overweight or obese status (40.3%) compared to those who did not (36.2%).

The regional and urban/rural geography variables showed that almost 40% of Aboriginal children and youth living in the Atlantic provinces, Quebec and Ontario were either overweight or obese. In small population centres, the proportion of children and youth who were overweight or obese was 42.5%, followed by medium population centres (38.9%), large population centres (35.7%) and rural areas (34.4%).

The bivariate relationships between the school environment variables and overweight were unclear. Children and youth in school environments that were rated the most positive were the most likely to be obese (18.4%), although those in the third quartile were the least likely to be obese (12.8%). Those rating their school environments the least negatively were the most likely to be obese (24.1%), while those with the most negative school environment rating were the least likely (13.0%).

We investigated the adjusted associations between these variables and children's weight status using sequential multivariate logistic regression (Table 2). In Model I, only food security and demographic variables were included, and those with very low food security had higher odds of being obese or overweight (OR = 1.54, 95% CI: 1.11–2.15). In Model II, other household variables were added, and the effect of food security fell below significance. Mother's educational attainment, family structure and crowding had no significant independent effects, but those in the third (OR = 0.76, 95% CI: 0.59–0.97) and fourth (OR = 0.72, 95% CI: 0.55–0.95) income quartiles were significantly less likely to be overweight or obese than those in the first (lowest) quartile.

School environment variables were added in Model III. A positive school environment rating was unrelated to overweight or obesity, while those in the second, third and fourth quartiles of "negative" school environment were more likely to be overweight or obese than those in the first quartile. Those whose school environments were rated the most negatively were the most likely to be overweight or obese, relative to those who rated their school environments the least negatively (OR = 1.43, 95% CI: 1.11–1.84).

Model IV added geographic variables. Rural or urban residence had no effect, independent of the other variables, but First Nations and Métis children in British Columbia (OR = 0.65, 95% CI: 0.50–0.86) and the three territories (OR = 0.68, 95% CI: 0.49–0.95) were less likely to be overweight or obese, controlling for the other variables in the model.

Lastly, Model V included the two cultural variables—exposure to an Indigenous language and family members having attended residential schools. Neither had a significant independent effect on obesity status.

Discussion

This study provides additional evidence that Indigenous children and youth are at higher risk of overweight and obesity than are other Canadian children. Among youth aged 12 to 17 years in our study sample, 30% were classified as either overweight or obese, compared with 20.7% of all Canadian youth in 2013.[30] First Nations and Métis girls were less likely to be overweight or obese than were boys, an observation that is consistent with previous literature on weight status and sex/gender.[16,31,32]

Given that Indigenous children and youth are at a higher risk of overweight and obesity and the potential for weight to impact health outcomes over the life course,[4-7] it is important to understand the distal and "upstream" determinants that drive their weight status. The data shown here support the importance and utility of a socio-ecological perspective for those ends.[8]

There has been little exploration of the relationship between food security and weight status among Indigenous children and youth, despite research suggesting its importance for the health of Aboriginal peoples more generally.[33] Research on the relationship between food insecurity and obesity or overweight among children and youth has thus far been inconclusive, as studies have found either a positive association between food insecurity and obesity[15,34-36] or insignificant results.[37-39] There are only a few Canadian studies examining the food insecurity–obesity relationship.[14,40,41]

Overall, this study found that food insecurity is indeed a risk factor for overweight or obesity among Indigenous children, with children in very food-insecure households having significantly higher odds of

TABLE 2
Logistic regression analysis estimating overweight and obesity among First Nations and Métis youth aged 6 to 17 years, Canada, 2012

Variable	Model I OR (95% CI)	Model II OR (95% CI)	Model III OR (95% CI)	Model IV OR (95% CI)	Model V OR (95% CI)
Household food security status					
Marginal or high food security (ref)	1.00	1.00	1.00	1.00	1.00
Low food security	1.15 (0.89–1.50)	1.01 (0.77–1.33)	0.99 (0.75–1.31)	1.00 (0.75–1.33)	0.99 (0.74–1.32)
Very low food security	1.54[a] (1.11–2.15)	1.31 (0.91–1.90)	1.29 (0.89–1.86)	1.34 (0.93–1.92)	1.32 (0.92–1.89)
Age group					
6–11 years (ref)	1.00	1.00	1.00	1.00	1.00
12–17 years	0.43[a] (0.37–0.50)	0.43[a] (0.37–0.51)	0.41[a] (0.34–0.49)	0.41[a] (0.34–0.49)	0.41[a] (0.34–0.49)
Gender					
Male (ref)	1.00	1.00	1.00	1.00	1.00
Female	0.76[a] (0.65–0.88)	0.75[a] (0.65–0.88)	0.76[a] (0.65–0.89)	0.76[a] (0.65–0.89)	0.75[a] (0.64–0.88)
Indigenous identity					
First Nations (ref)	1.00	1.00	1.00	1.00	1.00
Métis	0.81[a] (0.67–0.98)	0.85 (0.69–1.04)	0.85 (0.69–1.05)	0.83 (0.68–1.02)	0.86 (0.70–1.06)
Mother's educational attainment					
Less than secondary school (ref)	—	1.00	1.00	1.00	1.00
Secondary school or equivalent	—	1.15 (0.85–1.57)	1.18 (0.87–1.59)	1.16 (0.86–1.58)	1.18 (0.87–1.59)
Some post-secondary	—	1.08 (0.77–1.51)	1.11 (0.80–1.53)	1.11 (0.80–1.54)	1.11 (0.80–1.54)
Post-secondary certificate, diploma or degree	—	0.94 (0.73–1.21)	0.95 (0.74–1.22)	0.95 (0.74–1.21)	0.94 (0.74–1.21)
Annual household income per capita					
1st quartile (< $9510) (ref)	—	1.00	1.00	1.00	1.00
2nd quartile ($9510–$16 680)	—	0.90 (0.70–1.15)	0.91 (0.71–1.16)	0.92 (0.72–1.18)	0.93 (0.73–1.19)
3rd quartile ($16 690– $27 260)	—	0.76[a] (0.59–0.97)	0.76[a] (0.59–0.98)	0.76[a] (0.59–0.98)	0.77[a] (0.60–0.98)
4th quartile (> $27 280)	—	0.72[a] (0.55–0.95)	0.74[a] (0.57–0.97)	0.75[a] (0.57–0.98)	0.76[a] (0.58–1.00)
Family structure					
Two-parent family (ref)	—	1.00	1.00	1.00	1.00
Lone-parent family	—	1.13 (0.94–1.36)	1.12 (0.93–1.35)	1.13 (0.93–1.37)	1.11 (0.91–1.34)
Other	—	0.91 (0.59–1.40)	0.92 (0.60–1.40)	0.90 (0.59–1.37)	0.95 (0.62–1.45)
Household crowding					
One or fewer people per room (ref)	—	1.00	1.00	1.00	1.00
More than one person per room	—	1.02 (0.73–1.43)	1.01 (0.72–1.42)	1.02 (0.72–1.44)	0.99 (0.70–1.39)
Positive school environment index					
1st quartile (1.00–2.75) (ref)	—	—	1.00	1.00	1.00
2nd quartile (3.00–3.00)	—	—	1.08 (0.82–1.44)	1.09 (0.82–1.44)	1.09 (0.82–1.43)
3rd quartile (3.25–3.67)	—	—	0.95 (0.70–1.28)	0.94 (0.69–1.27)	0.93 (0.69–1.25)
4th quartile (3.75–4.00)	—	—	1.12 (0.82–1.55)	1.10 (0.80–1.50)	1.09 (0.80–1.48)

Continued on the following page

TABLE 2 (continued)
Logistic regression analysis estimating overweight and obesity among First Nations and Métis youth aged 6 to 17 years, Canada, 2012

Variable	Model I OR (95% CI)	Model II OR (95% CI)	Model III OR (95% CI)	Model IV OR (95% CI)	Model V OR (95% CI)
Negative school environment index					
1st quartile (1.00–1.60) (ref)	—	—	1.00	1.00	1.00
2nd quartile (1.75–2.00)	—	—	1.29[a] (1.02–1.62)	1.29[a] (1.03–1.62)	1.28[a] (1.03–1.60)
3rd quartile (2.20–2.25)	—	—	1.44[a] (1.10–1.90)	1.41[a] (1.07–1.85)	1.39[a] (1.06–1.82)
4th quartile (2.40–4.00)	—	—	1.43[a] (1.11–1.84)	1.40[a] (1.08–1.81)	1.38[a] (1.07–1.78)
Regional geography					
Atlantic	—	—	—	0.94 (0.59–1.49)	0.94 (0.60–1.48)
Quebec	—	—	—	0.98 (0.72–1.34)	0.97 (0.72–1.32)
Ontario (ref)	—	—	—	1.00	1.00
Prairies	—	—	—	1.00 (0.75–1.31)	0.95 (0.73–1.24)
British Columbia	—	—	—	0.65[a] (0.50–0.86)	0.64[a] (0.49–0.83)
Territories	—	—	—	0.68[a] (0.49–0.95)	0.64[a] (0.45–0.89)
Urban/rural geography					
Rural (ref)	—	—	—	1.00	1.00
Small population centre	—	—	—	1.21 (0.93–1.58)	1.19 (0.91–1.56)
Medium population centre	—	—	—	1.15 (0.84–1.57)	1.13 (0.83–1.55)
Large population centre	—	—	—	0.96 (0.74–1.25)	0.97 (0.75–1.26)
Exposure to Indigenous language					
No (ref)	—	—	—	—	1.00
Yes	—	—	—	—	1.17 (0.99–1.40)
Family members attended residential schools					
No (ref)	—	—	—	—	1.00
Yes	—	—	—	—	1.02 (0.84–1.23)
Not stated	—	—	—	—	0.85 (0.65–1.10)
C-Statistic	0.62	0.63	0.63	0.64	0.64

Data source: 2012 Aboriginal Peoples Survey.

Abbreviations: CI, confidence interval; OR, odds ratio; ref, reference category.

Notes: Sample numbers according to BMI (normal weight: n = 4310; overweight: n = 1560; obese: n = 1030). Values shown in the table are bootstrapped estimates. Model I included household food security and demographic variables. Model II added socioeconomic status variables and family-level factors. Model III included school environment variables. Model IV added geographic variables. Model V incorporated all variables by adding cultural factors.

[a] Significantly different from reference category ($p < .05$).

overweight or obesity, controlling for demographic factors. However, food insecurity did not have a significant effect independent of other household-level socioeconomic variables. As expected, household income is a significant predictor of weight status among Aboriginal children. Household income is an important determinant of numerous health outcomes as it can represent access to resources and recreational and physical activity opportunities for families, and is also a key factor in food security. Neither mother's education nor residential schooling of a family member were significant once income was controlled.

The socioecological approach led us to consider characteristics of schools as predictors of overweight and obesity. Our study uncovered an unexpected factor, perception of school environment, as an important predictor of weight status for children and youth. Although positive perceptions had no relationship to weight status, negative perceptions of school environment (including exposure to racism, bullying, alcohol, drugs or violence) were associated with an increased likelihood of obesity or overweight, independent of

household socioeconomic and demographic characteristics. Understanding these results requires further investigation, but it has been suggested elsewhere that schools with negative climates may also be less likely to offer effective opportunities for physical activity.[42]

Regional geography appeared to have an impact on weight status, as children and youth living in British Columbia or the three territories were significantly less likely to be overweight or obese compared to children living in Ontario, controlling for household socioeconomic characteristics. Similar variation has been observed previously, and some research suggests that greater emphasis on outdoor physical activity and availability of facilities may be partially responsible for the observed difference in weight status across provinces.[43] In addition, socioeconomic status[44,45] as well as being born outside of Canada[44] has been inversely associated with a lower BMI among adults in several provinces, including British Columbia.

Somewhat surprisingly, however, there was no difference between Indigenous children and youth living in rural, small, medium or large cities in their odds of being overweight or obese, suggesting that the more important factors were operating at the household and school levels.

Given previous literature on the determinants of Indigenous peoples' health, we had expected to find that exposure to an Indigenous language, as a measure of cultural preservation, would be protective against being overweight or obese, and that having a family member who attended residential schools would be a risk factor. Although neither had an independent effect, it must be recognized that these measures included in the APS are only weak measures of cultural attachment or preservation. Further research is necessary to understand whether cultural factors might be related to overweight and obesity at the population level, and if so, in what way.

Strengths and limitations

No other studies to date have examined the relationship between food insecurity and obesity among Aboriginal children and youth at the population level. This study used a national survey with the largest available sample size of Indigenous children and youth.

A key limitation of this study, as well as many others investigating the food insecurity–obesity relationship, is that the design is cross-sectional and does not allow us to establish causation or explore how the relationship changes over time. Subjective BMI data were collected, as caregivers were asked to report their children's height and weight. This may have resulted in an underestimate of the prevalence of obesity, as research shows that parents tend to underestimate their children's weight and overestimate height, leading to a lower BMI than when objectively measured.[45,46] Covariates not measured in this study, such as physical activity and diet, could be responsible for confounding effects. Additionally, given that this is not a well-studied topic, we were not able to compare this association in Aboriginal children and youth with any similar associations in the general Canadian population.

It is also difficult to compare our results with other studies, because different measures are used to assess food insecurity. The United States uses the Agricultural Department Food Security Scale,[47] which is different from the measures used in the APS or the Canadian Community Health Survey, limiting comparisons. Moreover, while the literature discusses the importance of including culture and access to traditional foods for an Aboriginal definition of food security,[8,9] the APS food security questions do not include these dimensions.

Conclusion

We concluded that off-reserve Indigenous children and youth who are in households with very low food security are indeed at higher risk for overweight and obesity, but that this excess risk is not independent of household socioeconomic status; household income adjusted for household size are reliable predictors. This suggests that household socioeconomic status is a major contributor to the high risk of overweight and obesity among First Nations and Métis children and youth. We also found that being in a negative school environment is associated with obesity risk, independent of demographic, household and geographic factors.

Given the complexity of childhood obesity and overweight, the available data limited our ability to identify conclusively the factors that are most important, including the potential role of food insecurity. There is a lack of longitudinal data to help us understand the interplay of various factors over the life course in different populations. Among Indigenous peoples specifically, community-based participatory research and research using qualitative methods would strongly complement quantitative investigations. Previous research on interventions in Aboriginal communities demonstrates the strength of such an approach.[33,41,42]

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Conflicts of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

Authors' contributions

JB conceived the idea for the paper, conducted the literature review and preliminary data analysis, and wrote the first draft. MC assisted with the data analysis and manuscript draft, revised the paper and is principal investigator (PI) on the supporting grant. YG conducted the data analysis, and revised and commented on later drafts. PW supervised the data analysis and is co-PI on the supporting grant. All authors read and approved the final manuscript.

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Status report

Childhood overweight and obesity in Canada: an integrative assessment

Deepa P. Rao, PhD; Erin Kropac, MSc RD; Minh T. Do, PhD; Karen C. Roberts, MSc; Gayatri C. Jayaraman, PhD

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Abstract

Introduction: Obesity is a complex risk factor for chronic disease that is associated with a number of socioecological determinants. In this status report, we provide an overview of the socioecological framework that is now guiding our ongoing surveillance efforts in the area of childhood overweight and obesity. This framework considers individual risk and protective factors (sociodemographic, lifestyle, psychosocial and early-life) through the lens of the life stage, levels of influence and environments in which these factors play a role.

Methods: Using data from the Canadian Community Health Survey and the Canadian Health Measures Survey, univariate and bivariate analyses were used to report on behavioural, psychosocial, and early life factors associated with excess weight among Canadian children.

Results: Estimates of early-life (e.g. breastfeeding), behavioural (e.g. physical activity), and psychosocial factors (e.g. sense of community) are presented as they relate to age group, sex, income adequacy and weight status.

Conclusion: Building upon our recent reporting on trends in and sociodemographic factors associated with childhood obesity in Canada, this work illustrates the remaining risk and protective factors shown in our surveillance framework. This analysis supports the shift towards a holistic appraisal of determinants related to healthy weights.

Keywords: *overweight, obesity, children, youth, sociodemographic factors*

Highlights

- The surveillance of overweight and obesity trends in children and youth is important in informing research, programs and policies.
- Early-life, behavioural and psychosocial factors are related to excess weight in childhood.
- A greater proportion of normal weight children report consuming a healthy diet, which is a suggested behavioural protective factor, than obese children.
- A large majority of mothers report breastfeeding their children, which is a suggested early-life protective factor.

Introduction

In recent years, there has been a shift away from the "eat-less-move-more" paradigm of excess weight towards one that recognizes the multifactorial etiology of obesity and the importance of integrating a full socioecological, or integrative, understanding of its associated risk and protective factors.[1] Given the persistently high levels of excess weight among Canadian children and youth,[2] an integrated appraisal of its associated factors may inform our understanding of the health of this population to assist with public health efforts. This broader perspective is one that the Centre for Chronic Disease Prevention has similarly adopted for a variety of Public Health Agency of Canada (PHAC) surveillance initiatives.[3-6]

In this status report, we provide an overview of the socioecological framework that is now guiding PHAC's ongoing surveillance efforts in the area of childhood overweight and obesity. This framework considers individual risk and protective factors (sociodemographic, lifestyle, psychosocial and early-life) through the lens of the life stage, levels of influence and environments in which these factors play a role (Figure 1). Building upon our recent reporting on trends in and sociodemographic factors associated with childhood obesity in Canada,[2] this work illustrates the remaining (lifestyle, psychosocial and early-life) risk and protective factors shown in this surveillance framework. This integrated appraisal of factors also links to childhood obesity reporting included in the Chronic Disease and Injury Indicator Framework (CDIIF),[4] which is an important PHAC resource to guide research, programs and policy in Canada.

Methods

Data and data sources

We analyzed data from two population-based national health surveys for this paper: the Canadian Community Health Survey ([CCHS] Annual Component, 2014[7] and 2011–12,[8] and Mental Health Component, 2012[9]) and the Canadian Health Measures

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Survey ([CHMS], cycle 3, 2012/13[10]). We identified factors associated with excess weight within each survey, according to the levels of influence presented in Figure 1. Lifestyle factors included healthy diet, sugar-sweetened beverage consumption, physical activity, sedentary behaviour and sleep. Psychosocial and early-life factors included mood disorders and depression, self-perceived physical health, happiness, sense of community, trustworthy relationships and breastfeeding. The distribution of each factor according to sex, age group, income adequacy and weight status were examined, except for breastfeeding.

Statistical analyses

We classified weight status (normal, overweight, obese) using the WHO classification system,[11] and adjusted self-reported estimates using a correction factor.[12] We completed descriptive statistics using SAS Enterprise Guide version 5.1 (SAS Institute Inc., Cary, NC, USA). We weighted point estimates to reflect the Canadian household population and calculated 95% confidence intervals using bootstrap resampling methods.

Results and discussion

Lifestyle factors

Eating behaviours

A healthy diet provides the necessary nutrients for growth and development.[13] Healthy eating patterns and behaviours established in childhood form the foundation of lifelong healthy eating.[14] In the absence of detailed and regularly collected measures of healthy eating, surveillance of food consumption and general meal behaviours among children provide our best proxy measures of healthy eating.[15] To that end, national-level data on the consumption of vegetables, fruit and sugar-sweetened beverages provide an indication of eating behaviours among Canadian children and youth.

Vegetable and fruit consumption is a validated proxy measure for diet quality;[15] the consumption of 5 or more servings of vegetables or fruits per day is suggestive of a healthy diet.[15,16] Fewer than half of Canadian children and youth maintain a healthy diet (Table 1). Youth with better income adequacy and weight status consume a healthier diet (Table 1). While meal (breakfast, lunch, dinner) patterns of Canadian children are supportive of healthy dietary behaviours, the prevalence

FIGURE 1
Socioecological surveillance framework of childhood overweight and obesity: individual risk and protective factors, environment and level of influence

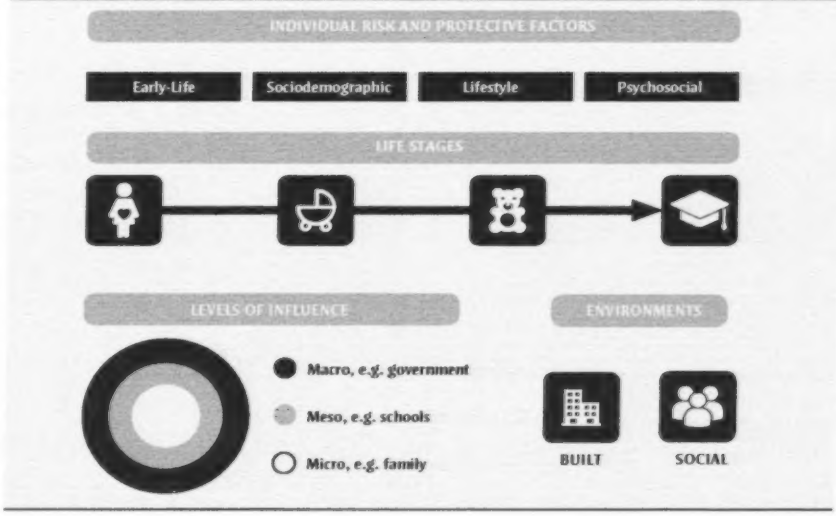

TABLE 1
Lifestyle factors associated with childhood obesity, Canada, CCHS 2014 and CHMS 2012/13

		Prevalence (%)	95% CI
Lifestyle factors			
Eating behaviours			
Healthy diet[a,c]			
Overall		43.6	41.7–45.5
Sex	Boys	39.3	36.7–41.9
	Girls	48.2	45.4–50.9
Income adequacy	Low	40.0	34.3–45.7
	Moderate	39.7	35.0–44.4
	High	48.8	45.9–51.6
Weight status	Normal	46.9	43.9–49.9
	Overweight	44.8	39.9–50.3
	Obese	37.1	30.7–43.5
Sugar-sweetened beverages[b,d]			
Overall		17.2	13.3–21.2
Sex	Boys	20.2	13.9–26.5
	Girls	14.2	9.6–18.7
Age group	5–11 years	13.4	9.7–17.0
	12–17 years	21.3	14.8–27.8
Income adequacy	Low	24.6	17.8–31.4
	Moderate	18.6	13.3–23.8
	High	10.6	5.4–15.9
Weight status	Normal	15.7	10.6–20.9
	Overweight	20.3	15.5–25.0
	Obese	21.5	10.7–32.2

Continued on the following page

TABLE 1 (continued)
Lifestyle factors associated with childhood obesity, Canada, CCHS 2014 and CHMS 2012/13

		Prevalence (%)	95% CI
Movement behaviours			
Physical activity[b,c]			
Overall		9.3[E]	5.8–12.8
Sex	Boys	12.6[E]	6.3–18.9
	Girls	5.9	4.1–7.6
Age group	5–11 years	13.5	8.9–18.2
	12–17 years	5.0[E]	2.7–7.3
Income adequacy	Low	5.5[E]	2.3–8.8
	Moderate	11.3[E]	4.9–17.7
	High	10.2[E]	6.2–14.3
Sedentary behaviour[b,f]			
Overall		48.1	42.6–53.6
Overall hours		8.4	8.3–8.5
Sex	Boys	46.0	39.5–52.5
	Girls	50.1	44.1–56.2
Age group	5–11 years	71.1	64.5–77.6
	12–17 years	23.8	17.2–30.4
Income adequacy	Low	47.8	40.6–55.1
	Moderate	45.9	36.9–55.0
	High	49.3	42.4–56.3
Weight status	Normal	52.6	46.6–58.5
	Overweight	41.8	32.5–51.0
	Obese	37.0	24.0–50.0
Sleep[b,g]			
Overall		74.6	70.0–79.2
Overall hours		9.0	8.8–9.1
Sex	Boys	74.8	67.9–81.8
	Girls	74.3	69.2–79.5
Age group	5–11 years	81.8	77.1–86.4
	12–17 years	67.0	60.0–74.0
Income adequacy	Low	77.5	72.3–82.7
	Moderate	73.9	66.6–81.2
	High	61.1	40.6–81.7
Weight status	Normal	77.5	72.3–82.7
	Overweight	73.9	66.6–81.2
	Obese	61.1	40.6–81.7

TABLE 1 (footnotes)

Source: Statistics Canada, CCHS 2014, ages 12–17, and CHMS 2012/13, ages 5–17.

Abbreviations: CCHS, Canadian Community Health Survey; CHMS, Canadian Health Measures Survey; CI, confidence interval.

Note: Estimates of physical activity guideline adherence by weight status were suppressed due to high variability.

[a] Data from CCHS 2014, ages 12–17.

[b] Data from CHMS 2012/13, ages 5–17.

[c] Consumption of 5 or more fruits or vegetables per day.

[d] Consumption of ≥ 1 sugar-sweetened beverage per day.

[e] Adherence based on Canadian Physical Activity Guidelines[20] (60 minutes of moderate- to vigorous-intensity aerobic physical activity every day).

[f] Adherence based on Canadian Sedentary Behaviour Guidelines[20,22] (no more than 2 hours/day of recreational screen time).

[g] Adequate sleep based on National Sleep Foundation Guidelines[21,24] (10–13 hours for children aged 5 years; 9–11 hours for children aged 6–13 years; and 8–10 hours for children aged 14–17 years).

[E] Interpret with caution due to high sampling variability (coefficient of variation between 16.6% and 33.3%).

of breakfast consumption remained stable between 2002 and 2010, with 3 in 5 children between the ages of 11 and 15 years eating breakfast on weekday mornings.[13] Among children aged 11 years, 75% of boys and 69% of girls reported consuming breakfast, compared to 59% and 46% of boys and girls aged 15 years, respectively.[17]

Children often choose snacks in lieu of meals, particularly through adolescence. However, it is encouraging that the percentage of children and youth consuming potato chips and sweets on a daily basis had decreased significantly from 2002 to 2010.[13] Limiting the consumption of sugary drinks is also encouraged as part of a healthy diet.[18,19] A substantial proportion of children and youth (17.2%, 95% CI: 13.3–21.2) are drinking soft drinks, fruit drinks or sports drinks daily (Table 1). Individuals with low income adequacy consume higher levels of such beverages than their higher income counterparts (Table 1).

All-movement behaviours

Over the course of the 24-hour day, people engage in activity of varying intensity: moderate-to-vigorous physical activity, light activity, sedentary behaviour and sleep. An exceptionally low proportion of Canadian children (Table 1) are obtaining the amount of physical activity recommended by Canadian guidelines.[20] Notably, guideline adherence appears to decrease with age (Table 1), while weight increases with age, as described in our earlier article.[2]

Sedentary behaviours, such as watching TV, playing passive video games and using a computer, have been associated with obesity.[21] Canadian children and youth engage in an average of 8.4 hours (95% CI: 8.3–8.5) of sedentary activity each day. Canadian sedentary behaviour guidelines provide cut-offs for screen-based behaviours in children,[22] and recent data[10] suggest that 48.1% (95% CI: 42.6–53.6) adhere to these recommendations (Table 1). Sleep is also associated with obesity in children, with short sleep duration identified as a risk factor for excess weight.[23]

The data[30] suggest that approximately one-quarter of children and youth do not obtain adequate sleep (Table 1) based on the latest recommendations.[24] Furthermore, a significantly higher proportion of young children accumulate adequate sleep than youth (Table 1).

Supportive environments, such as schools, are key venues for physical activity engagement. Between 2006 and 2011, there was a 57% increase in the number of schools in Canada with a fully implemented policy for daily physical education.[25] Active transport, or physically active means of transportation such as walking, can contribute to a child's daily physical activity; however, it is estimated that only one-third (32.5%) of children aged 11 to 15 years used active transportation to get to school.[26] A large majority of school administrators in Canada report that students have access to built environment resources such as bicycle racks (79%), change rooms (75%), outdoor facilities (89%) and gyms (84%) during and outside of school hours.[25] In 2010, approximately 24% of parents cited safety concerns as a barrier to children playing outside.[27] In the same year, 93% of parents said that public facilities and programs were available for their children, but a lower proportion (65%) said that these facilities and programs met their needs.[28]

Psychosocial factors

Internal psychological state and external social (interpersonal) relationships are factors that can precede the development of obesity, as well as outcomes that may arise as a result of weight status.[29,30] As a result, people living with obesity are often affected by fear, anxiety and/or depression.[31] While youth report experiencing mood disorders or depression (4.0%, 95% CI: 3.3–4.8), findings do not demonstrate differences based on weight status (Table 2). Nevertheless, how individuals perceive their appearance, abilities and uniqueness can impact their weight status.[32] Recent data demonstrate that obese youth are less likely to report that they are in good health (Table 2). The stability of happiness across weight categories (Table 2), however, suggests that weight does not associate strongly with self-concept, as might be expected.[33]

With respect to external outlook, although social isolation has been associated with excess weight,[34] when we examined children's reported sense of community and

TABLE 2
Psychosocial and early-life factors associated with childhood obesity, Canada, CCHS 2011-12, 2012 and 2014

		Prevalence (%)	95% CI
Psychosocial factors			
Mental health			
Mood disorder and depression[a]			
Overall		4.0	3.3–4.8
Sex	Boys	2.8[E]	1.8–3.8
	Girls	5.4	4.2–6.5
Income adequacy	Low	6.1	4.1–8.0
	Moderate	3.8	2.6–4.9
	High	3.2	2.1–4.4
Weight status	Normal	3.3	2.3–4.3
	Overweight	4.6	2.5–6.7
	Obese	3.6	1.6–5.7
Internal perceptions of self			
In good health[a]			
Overall		69.9	67.8–72.0
Sex	Boys	70.6	67.9–73.4
	Girls	69.1	66.1–72.1
Income adequacy	Low	60.1	54.8–65.4
	Moderate	66.1	62.3–69.8
	High	76.1	73.6–78.5
Weight status	Normal	75.2	72.6–77.8
	Overweight	67.7	62.4–73.0
	Obese	51.8	45.2–58.5
Happy[b]			
Overall		90.9	89.7–92.1
Sex	Boys	93.0	91.5–94.5
	Girls	88.7	86.8–90.6
Income adequacy	Low	87.9	84.5–91.2
	Moderate	90.7	88.2–93.3
	High	92.4	90.8–94.1
Weight status	Normal	91.0	89.4–92.6
	Overweight	89.3	85.8–92.7
	Obese	90.1	86.2–93.9
External outlook			
Strong sense of community[a]			
Overall		79.6	77.9–81.3
Sex	Boys	77.3	74.7–79.8
	Girls	82.1	79.6–84.5
Income adequacy	Low	78.8	75.3–82.2
	Moderate	79.1	76.6–81.7
	High	81.2	77.4–85.0

Continued on the following page

TABLE 2 (continued)
Psychosocial and early-life factors associated with childhood obesity, Canada, CCHS 2011-12, 2012 and 2014

		Prevalence (%)	95% CI
Weight status	Normal	79.6	77.4–81.9
	Overweight	80.3	75.8–84.8
	Obese	80.1	75.3–85.0
Trustworthy relationships[b]			
Overall		96.3	95.5–97.1
Sex	Boys	96.1	94.9–97.2
	Girls	96.6	95.4–97.8
Income adequacy	Low	93.4	91.0–95.9
	Moderate	96.2	94.8–97.6
	High	97.8	97.0–98.5
Weight status	Normal	96.7	95.7–97.7
	Overweight	95.8	93.6–98.0
	Obese	95.0	92.4–97.7
Early-life factors			
Breastfeeding			
Mothers who breastfed their child[c]		89.3	88.0–90.6
Mothers who exclusively breastfed their child for 6 months[c]		26.2	24.1–28.3

Source: Statistics Canada, CCHS—Mental Health Component, 2012; CCHS 2011-12; and CCHS—Annual Component, 2014. Data is for children ages 12–17.

Abbreviations: CCHS, Canadian Community Health Survey; CI, confidence interval.

[a] Data from CCHS—Annual Component, 2014.

[b] Data from CCHS—Mental Health Component, 2012.

[c] Data from CCHS 2011-12.

[E] Interpret with caution due to high sampling variability (coefficient of variation between 16.6% and 33.3%).

having trustworthy relationships, we observed no significant patterns on the basis of weight status (Table 2). Nevertheless, these psychosocial factors are also early-life factors that can affect health and weight at later ages.[29]

Early-life factors

A mother's preconception weight and her weight gain during pregnancy are two important prenatal factors associated with childhood obesity.[35,36] Women with high weight gain during pregnancy were at higher risk of having large-for-gestational-age babies, while those with low weight gain were at high risk for preterm birth and small-for-gestational-age babies.[35] Recent estimates suggest that one-third of Canadian women entering into pregnancy were overweight or obese and slightly less than half (48.7%) of women were gaining more than recommended.[37] In addition, child resemblance to parental (mother or father) body weight has been shown to be a result of complex interactions between environmental and genetic factors.[36,38,39]

Breastfeeding has been associated with lower rates of childhood obesity, and a majority of women who gave birth within a hospital or clinic in Canada were offered help by a health care professional to initiate breastfeeding within a half hour of birth.[35,40] In Canada, a large majority of mothers reported having breastfed their child, with roughly a quarter doing so exclusively for the child's first six months of life (Table 2).

Maternal smoking during pregnancy was also associated with child weight, with a 2.26 (95% CI: 1.23–4.15) odds of childhood obesity.[41] Roughly 10.5% of pregnant Canadian women smoke daily.[35]

Conclusion

Childhood obesity is a complex health issue impacted by a number of socioecological factors. While differences in individual risk and protective factors were not apparent on the basis of excess weight in childhood (except for healthy eating), childhood obesity has been shown to track into adulthood,[42] where these impacts may be more visible. The ongoing surveillance of overweight and obesity in children and youth, as well as the factors impacting them, helps to inform an understanding of population trends that can benefit future health efforts.

Conflicts of interest

The authors declare that there is no conflict of interest.

Authors' contributions

All authors were involved in the conceptualization and interpretation of the study. DPR was involved in the analysis of the data, and DPR, KCR, EK and MTD were involved in the drafting of the manuscript.

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Status report

Identifying equity-focussed interventions to promote healthy weights

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Abstract

Introduction: We developed screening criteria to identify population health interventions with an equity focus for inclusion on the Public Health Agency of Canada's Canadian Best Practices Portal. We applied them to the area of "healthy weights," specifically, obesity prevention.

Methods: We conducted a review of the literature and obtained input from expert external reviewers on changes to midstream environments. Interventions had to identify outcomes for groups with an underlying social disadvantage. We included papers with a focus on equity and vulnerable populations, intervention and/or evaluation studies, social determinants of health and healthy weights or obesity prevention. We then appraised the shortlisted studies for quality of evidence to determine eligibility for inclusion as promising practices on the Canadian Best Practices Portal.

Results: Few of the references reviewed passed the equity screening criteria (26 out of 2823 published papers reviewed, or 0.9%). Six (of the 26) interventions qualified as promising practices.

Conclusion: The ability of the equity screening criteria to distinguish midstream-level interventions for obesity prevention suggests that the criteria have potential to be applied to other public health topics. What is most important about our work is that the Portal, which is no longer being updated but is still accessible, was broadened to include interventions with a focus on equity.

Keywords: *intervention studies, equity, vulnerable populations, social determinants of health, obesity, healthy weights, population health, best practices, midstream environments*

Highlights

- We developed screening criteria to identify equity-focussed, population-health interventions for inclusion on the Canadian Best Practices Portal.
- The criteria were based on the literature and input from experts. We used the area of "healthy weights"—specifically, obesity prevention—to test the equity screening criteria.
- Few of the references reviewed passed our equity screening criteria (26 out of 2823). Six interventions qualified as promising practices.
- Our criteria have potential to be applied to other public health topics.

Introduction

There is significant evidence that the burden of chronic disease is not evenly distributed across the population in Canada. These health inequities do not occur randomly; instead, they point to differences in the distribution of the social determinants of health (e.g. education, employment, income, gender, etc).[1-5] For example, people with fewer social and economic advantages are generally less healthy than those who are better off, suggesting a wealth-health gradient.[6] It is important to understand health differences that occur across population groups, in order to develop policies and programs that can reduce health inequities while improving health for all.[7]

This paper describes a project undertaken to identify best and/or promising practices associated with population health interventions that have an equity focus, for inclusion on the Canadian Best Practices Portal ("the Portal"). The Portal is a searchable database of effective population health interventions data and resources that is maintained by the Public Health Agency of Canada (PHAC). The project is part of PHAC's ongoing efforts to reduce health inequities and promote evidence-informed decision making.

Since 2006, the Portal has provided robust evidence to public health professionals so they can adapt and implement interventions most appropriate to their settings.

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PHAC describes "best and promising practices" as interventions, programs or initiatives that have demonstrated desired changes through the use of appropriate, well-documented research or evaluation methodologies.[8,9] *Best practices* have demonstrated, through multiple implementations, high impact (positive changes related to desired outcome); adaptability (and transferability to other settings); and high quality of evidence. *Promising practices* show potential (or "promise"); they may be in the earlier stages of implementation. They have demonstrated medium-to-high impact, high potential for adaptability and suitable quality of evidence (e.g. strong theoretical basis and rigorous evaluation study design).

Health equity

Braveman and Gruskin[10] propose that "... equity in health can be defined as the absence of disparities in health (or in the major social determinants of health) between social groups who have different levels of underlying social advantage/disadvantage—that is, different positions in a social hierarchy."[10,p.254] This operational definition highlights two important points for evaluating and measuring health equity outcomes. First, it suggests that an equity indicator should be able to distinguish changes in health disparities, i.e. it should be able to distinguish the underlying social advantage, disadvantage or gap.[11] A goal of public health is to reduce such gaps in health outcomes between people living in conditions of disadvantage and people living in comparatively more advantaged conditions, or to universally improve health outcomes across the social gradient for all.[12]

Second, Braveman and Gruskin's definition of health equity suggests that outcomes could also be measured at the midstream level of intervention. The midstream level is external to the individual person, and consists of environments or conditions in which people live, work, play and learn. An example of a midstream environment is the built environment (a measurable aspect of which is walkability). A midstream environment serves as a crucial linchpin between proximal, intraindividual factors (e.g. knowledge, attitudes, behaviours) and more distal, structural factors (e.g. policy, legislation, administrative activity).[13] Improvements in midstream environments help individuals to live healthier lives. Changes in midstream environments (midstream "outcomes") serve as intermediary markers of action to reduce health inequities, especially when the effects of interventions on health will likely happen further in the future.

Whitehead[14] suggested that health equity has moral and ethical dimensions—that some differences in health are avoidable and remediable and therefore unfair and unjust. These principles have become widely acknowledged in the field of population health. While health status is influenced by a complex array of biological factors, research suggests that health inequities also appear to be caused by underlying factors related to social position within a particular societal context.[15-20] Societal contexts create social stratification, which leads to differential exposure to health-damaging conditions, differential vulnerability and differential consequences of ill health.[15]

Project description

The purpose of the project was to populate the Portal with new interventions that have a focus on equity. We limited the project's scope of equity analysis to four social determinants of health: income, social inclusion, built environment and education or literacy. The purpose of the limit was to (1) test the relevance or relative strength of the social determinants as pathways to health equity; and (2) to ensure the project scope was realistic. The area of healthy weights, which is a priority for the Public Health Agency of Canada, was used to develop and test the criteria. Specifically, we focussed on obesity prevention. We chose this topic, in part, to explore the pathways that can influence healthier eating and physical activity by looking at the potential interactions among select social determinants of health.

Methods

Project steps

The project steps included

(1) developing a set of equity screening criteria that can be applied to different public health topics to identify interventions that act on the selected social determinants of health to promote health equity;

(2) conducting a search of published and grey literature for studies of relevant interventions on healthy weights and obesity prevention;

(3) reviewing existing healthy weights and obesity prevention interventions already on the Portal to avoid duplication;

(4) applying the equity screening criteria to the search results to generate a shortlist of relevant studies;

(5) appraising the quality of evidence of the shortlisted studies using the Portal's Intervention Assessment Screening Tool;

(6) contributing equity-specific fields to the Portal's Annotation Template, which is used to summarize key features of interventions; and

(7) using the Annotation Template to record information on the studies or interventions that passed the Assessment Tool.

These project steps were informed by several guiding papers on developing and implementing policies and programs that address underlying factors that contribute to inequities[21] and conducting reviews with a focus on health equity.[22,23]

Development of equity screening criteria

Midstream environments appear to influence health outcomes, including inequities[11] and obesity.[24-27] Examples of midstream environments specific to obesity prevention include food environments (e.g. whether healthier foods are affordable, which pertains to income as a social determinant of health) and physical activity environments (e.g. the walkability of the area, which pertains to the built environment as a social determinant of health).

Despite the importance of midstream environments on inequities and obesity, however, we were unable to find any criteria in the literature to screen for midstream, equity-focussed interventions. Therefore, we had to develop equity screening criteria for midstream interventions. Table 1 presents our equity screening criteria, which are specific to obesity prevention as a case example, but are intended to be adaptable to different public health topics.*

We developed the equity screening criteria based on a review of literature and feedback from five external reviewers with expertise related to population and public

* We approached screening without a predefined clinical definition of obesity. We selected papers about obesity, with obesity labelled or categorized by the authors.

TABLE 1
Equity screening criteria developed for the Canadian Best Practices Portal, as applied to the public health issue of obesity prevention

Characteristics	Inclusion criteria	Exclusion criteria
Time frame	Published within the last 10 years, i.e. 2003–2014 (this aligns with the Assessment Tool)	Published before 2003
Language	English	Language other than English
Geography	Worldwide	No exclusions
Type of document	Must be a *primary* source that reports on the findings of a study or evaluation (may be published literature or grey literature)	Document is an opinion piece, e.g. commentary, editorial, letter to the editor, or a news article
Topic of interest (focus)	Must explicitly mention obesity or overweight in/as one or more of the following: • Title and/or abstract • Intervention goal/objective • Intervention strategy/activity • Measured indicator or outcome • Downstream outcome (even if it is not yet measured)	• No explicit mention of obesity or overweight • Obesity/weight is positioned as a *predictor, risk factor*, or *correlate* of other conditions (e.g. heart disease), rather than as an *outcome* of an intervention • Deals with underweight • Deals with eating disorders • Concerns nutrition that does *not* relate to obesity: hunger; malnutrition; vitamins; minerals. (Note: Obesity-related nutrition includes fresh fruits and vegetables; energy dense foods (high in sugar, fat or calories); and whole grains)
Intervention	Must include an intervention, *and* must also meet one of these criteria: • Acts on key determinant(s) of health (i.e. income, social inclusion, built environment, education/literacy) at the organizational, institutional, community or population level in order to promote health equity for obesity prevention • Does not explicitly aim to promote health equity for obesity prevention in its goals/objectives or strategies, but the reported outcomes distinguish effects on health equity for obesity prevention	• An intervention is not mentioned • Intervention(s) mentioned, but focusses exclusively on the following (i.e. does not also act at the determinants level): – Medical determinants of health (e.g. health care, drug treatments, surgery) – Individual-level strategies (e.g. behavioural, diaries, lifestyle, curricular, self-management, coaching, counselling, motivational, skills training, informational) – The provision of portable equipment (e.g. pedometers, sports equipment)
Population	Must include one of the following: • A population that the authors specify as living in conditions of disadvantage (social, economic or geographic) • Midstream environments in which people live, work, learn or play (e.g. food environment, physical activity environment)	• Includes populations who are considered to be at higher risk of obesity due to genetics or biology rather than to social, economic or geographical conditions • Focusses only on populations living in more advantaged conditions
Evaluation	Must include an evaluation on the effects of an intervention, in one of the following ways: • In meeting intervention goals/objectives • In affecting people's morbidity, mortality, well-being or quality-of-life	• An intervention (possible or actual) is described, but no evaluation of its *effects* is reported • Formative or process evaluations are included but without *also* an evaluation of the *effects* of the intervention

Continued on the following page

health, health equity and social determinants of health. We reviewed literature on existing evidence and theory on midstream interventions to reduce health inequities and/or obesity, specifically those with visual conceptual models or organizing frameworks. The focus on midstream interventions was intended to strengthen the "evidence bridges" between action on environments and health equity outcomes. The types of literature we reviewed included systematic reviews, narrative reviews, conceptual papers and discussion papers. We presented the draft set of screening criteria to the external reviewers, who were asked what was most promising about the criteria, whether there were gaps in the criteria and if so how to

TABLE 1 (continued)
Equity screening criteria developed for the Canadian Best Practices Portal, as applied to the public health issue of obesity prevention

Characteristics	Inclusion criteria	Exclusion criteria
Outcomes	Must report *positive* outcomes for one of the following: **Midstream environments**—outcomes indicating availability, accessibility or affordability of health-promoting goods and services, such as: • Food (e.g. food security, fresh fruits and vegetables, energy dense foods, food deserts) • Physical activity (e.g. walkability, public facilities, public transit, green space, active transportation infrastructure) **People**—outcomes must be specific to people living in conditions of disadvantage (who may or may not be compared to people living in more advantaged conditions) and must be one of the following: • Weight-related (e.g. BMI) • Behaviour-related (e.g. consumption of fruits and vegetables, consumption of energy dense foods, physical activity, active transportation, sedentary lifestyle)	• The reported outcomes do not distinguish findings specific to people living in conditions of disadvantage (e.g., they may be part of the study sample, but outcomes are reported only for the sample as a whole) • There is no change in relevant outcomes, or they are negative • For **people** (not midstream environments), outcomes are reported *only* for knowledge or skills, without *also* being reported for weight-related or behavioural outcomes. (Note: Interventions that act at the determinants level use structural and environmental strategies to affect behaviours, morbidity and/or mortality, rather than exclusively using lifestyle strategies to affect knowledge, skills, perceptions and behaviour. Therefore, the salient outcomes for determinants-level strategies are behaviour and morbidity/mortality.)

address them and how to strengthen the criteria. We revised the draft criteria based on their feedback.

The finished equity screening criteria represented a new component in the Portal's assessment process. Key elements of the equity screening criteria align with the Portal's Assessment Tool (which considers impact, quality of evidence and source credibility). Interventions are not required to have a focus on equity to be accepted to the Portal, but after our project was complete, we additionally assessed all the interventions for an equity focus. The project design did not call for full testing of inter-rater reliability of the application of the equity screening criteria; however, a non-independent group of reviewers from the Propel Centre for Population Health Impact did review each potential intervention for quality of evidence as part of the usual assessment process for best or promising practices.

Search of published literature

In March 2014, we searched the published literature for papers with a focus on equity or vulnerable populations, intervention evaluation studies, the social determinants of health and healthy weights or obesity prevention. We imported a total of 3522 references into a RefWorks database: 2076 from MEDLINE; 685 from Embase and 660 from CINAHL (after duplicates of MEDLINE citations were removed); and 101 from snowball searching (following up on references cited in the papers reviewed). We reviewed 2823 of the 3522 references imported (80.2%), due to time constraints.

Search of grey literature

In March and April 2014, we searched over 100 websites of selected, relevant organizations related to health and obesity prevention, including Canadian and international government organizations, nongovernmental organizations, university-affiliated research centres, coalitions, networks and Listservs. We also sent emails to select stakeholders to request papers on evaluated interventions.

Portal Assessment Tool, Annotation Template, new equity fields and equity icon

The core of this project was the addition of equity screening criteria to the overall Portal assessment process for interventions. However, in order to populate the Portal, we also had to use the pre-existing Portal Intervention Assessment Screening Tool (Assessment Tool) to assess the impact, adaptability and quality of evidence of the interventions to determine if they met the requirements for a best or promising practice.

As part of our equity project, we had to revise the pre-existing Portal Intervention Annotation Template, which is used to capture information on interventions that have passed the Assessment Tool (i.e. best or promising practices), such as goals and objectives, outcomes, strategies or activities. The pre-existing Annotation Template was not designed to delineate the equity focus of interventions. Therefore, we added new fields to the Annotation Template to capture equity content from included studies and evaluations, and to contribute to the assignment of an "equity icon" indicating that the intervention passed the equity screening criteria.

The new fields included: (1) goals and/or objectives related to people living in conditions of disadvantage; (2) equity-focussed activities (e.g. activities that address economic, social or geographic barriers that limit access to opportunities and enabling resources for people living in conditions of disadvantage); and (3) reported outcomes specific to people living in conditions of disadvantage, and whether the findings were compared to those of people living in conditions of greater advantage.

Results

Published literature

Out of the 2823 references reviewed, 26 (0.9%) passed the equity screening criteria and were shortlisted as having both (1) equity content and (2) an evaluation of an intervention that acted at a midstream level to prevent obesity.

Grey literature

There were no additional evaluated interventions found in the grey literature (i.e. interventions that were not already on the Portal or found in the published literature) that passed the equity screening criteria. For example, some interventions may have included midstream-level strategies, but lacked an evaluation component or did not report findings specific to people living in conditions of disadvantage.

Selected interventions

Of the 26 shortlisted interventions, six (23%) passed the Assessment Tool as promising practices (none met the criteria for a best practice) and were annotated for the Portal. Table 2 presents a summary of the equity content and midstream-level strategies of these six interventions. Four interventions had a food or nutrition focus (e.g. vouchers for healthy foods; subsidized boxes of fruits and vegetables; changes to food environments). One intervention looked at the effect of changes to the built environment on physical activity. One study looked at the effects of moving to a less impoverished or an improved neighbourhood on obesity and the risk for diabetes. Five interventions were from the United States and one was from Australia. Low income was used as an indicator of inequity for all six interventions. The intervention strategies and reported outcomes of these studies reflected both health-related (person-level) and midstream levels. None of the findings were reported across the income gradient.

Twenty (77%) shortlisted interventions passed equity screening but did *not* pass

TABLE 2
Promising practices of health equity in obesity prevention interventions for the Canadian Best Practices Portal

References	Country	Equity content		
		Population	Intervention goal/strategy	Outcomes
Andreyeva T, Luedicke J, Middleton AE, Long MW, Schwartz MB. Positive influence of the revised Special Supplemental Nutrition Program for Women, Infants, and Children food packages on access to healthy foods. J Acad Nutr Diet. 2012;112(6):850-8. doi: 10.1016/j.jand.2012.02.019	United States	Low-income, pregnant and postpartum women with children 0–5 years of age	Provision of cash-value vouchers for healthy foods	Store-level data on the price, availability and variety of selected healthy foods in intervention stores vs. control stores
Black AP, Vally H, Morris P, Daniel M, Esterman A, Karschimkus CS, O'Dea K. Nutritional impacts of a fruit and vegetable subsidy programme for disadvantaged Australian Aboriginal children. Br J Nutr. 2013;110(12):2309-17. doi: 10.1017/S0007114513001700	Australia	Disadvantaged, low-income Aboriginal children (under age 18 years) living in rural area	Provision of subsidized weekly boxes of fruits & vegetables	Reported for disadvantaged, low-income children only
Coleman KJ, Shordon M, Caparosa SL, Pomichowski ME, Dzewaltowski DA. The healthy options for nutrition environments in schools (Healthy ONES) group randomized trial: using implementation models to change nutrition policy and environments in low income schools. Int J Behav Nutr Phys Act. 2012;9:80. doi: 10.1186/1479-5868-9-80	United States	Low-income schools	Changes to the school food environment. Other strategies: developing nutrition services as the main source for healthful eating; promoting school staff to model healthy eating	Reported for low-income schools only
Evans AE, Jennings R, Smiley AW, et al. Introduction of farm stands in low-income communities increases fruit and vegetable among community residents. Health Place. 2012;18(5):1137-43. doi: 10.1016/j.healthplace.2012.04.007	United States	Low-income, underserved neighbourhoods, which are designated as "food deserts"	Changes to the community food environment	Findings for low-income, underserved communities only
Gustat J, Rice J, Parker KM, Becker AB, Farley TA. Effect of changes to the neighborhood built environment on physical activity in a low-income African American neighborhood. Prev Chronic Dis. 2012;9(1):110165. doi: 10.5888/pcd9.110165	United States	Low-income neighbourhood	Changes to the built environment	Findings in intervention low-income neighbourhoods were compared to findings in matched low-income neighbourhoods
Ludwig J, Sanbonmatsu L, Gennetian L, et al. Neighborhoods, obesity, and diabetes—a randomized social experiment. N Engl J Med. 2011;365(16):1509-19. doi: 10.1056/NEJMsa1103216	United States	Low-income women living with children in public housing in high-poverty neighbourhoods	Provision of a low-poverty voucher to move to a neighbourhood that is less impoverished and counselling on moving	Findings in low-income women who received the intervention were compared to findings for low-income women in control conditions

the Assessment Tool. Half of these did not pass due to lack of (or limited) information concerning any guidelines, standards or theories used in the development of the intervention. The other half did not pass due to a "limited" rating for quality of evidence. A limited rating for evidence quality would be given for limited or poor sampling (e.g. a lack of, or no mention of, a number of individual participants followed over time); a lack of well-defined inclusion/exclusion criteria for the allocation to intervention control groups; a lack of validated outcome measures; a loss of participants to follow-up; or a lack of group differences identified and controlled for in the analysis.

Discussion

The goal of this project was to identify equity screening criteria and qualifying interventions with substantive equity focus using healthy weights, specifically, obesity prevention, as a case example, and to add to the Portal those interventions that met the criteria for either a best or a promising practice. Twenty-six references had relevant interventions with equity focus; six of these were found to be promising practices with sufficient quality of evidence using the Assessment Tool.

Strengths and limitations

In our test of the equity screening criteria, our ability to distinguish 26 midstream, equity-focussed interventions suggests that the criteria were able to screen for relevant interventions and could potentially be adapted for use with other public health topics. Our criteria were also able to distinguish equity outcomes based on the operational definition by Braveman and Gruskin.[10] This is crucial, as interventions intended to promote health equity must also be evaluable for health equity outcomes.

At a practical level, what is most important about our work is that the Portal now includes new interventions with equity focus. The addition of an equity icon makes it easier for users of the Portal (e.g. public health professionals) to find these interventions that have been effective in addressing health inequities. We want to note that as this paper was being written, we learned that the Portal will no longer be updated in the future, although it will remain online and accessible. While this means that the Portal will no longer be populated with new interventions, we have created a screening tool that may be used for identifying equity-focussed interventions. It may also be adapted for public health topics other than obesity prevention. In fact, our screening tool has been used (by others) to identify 41 equity-focussed interventions on the Portal for other public health topics. This work has been used in the creation of a document titled "Toward Health Equity: A Tool for Developing Equity-Sensitive Public Health Interventions."[28] This document serves as a practice tool to support the development of equity-sensitive public health interventions.

While we were able to find 26 relevant interventions, many others were excluded from our project because they were exclusively aimed at individual-level change, or clinical settings. This finding indicates that individual, behaviour-based interventions still dominate the field when it comes to obesity prevention. Among the 26 shortlisted interventions, only six met the standard for quality of evidence using the Assessment Tool. There may be additional interventions we did not find, because we reviewed only 80.2% of the references we reviewed in our published literature search. However, this does not affect our findings significantly, as we were not doing a comprehensive review, and were only looking to see whether our screening criteria could be applied to identify obesity prevention interventions with an equity focus.

All six of the included interventions qualified as promising practices using the Assessment Tool. None qualified as a best practice because the interventions (1) had short-term outcomes of less than six months; (2) had low impact (i.e. positive outcomes for a small proportion of the target population); (3) were only implemented once (e.g. a pilot); or (4) required specialized skills for implementation. The first two reasons relate to the duration and reach of the outcomes. The latter two reasons relate to external validity, or the extent to which a study or evaluation can be generalized to other populations and settings. In order to move from promising practices to best practices, future midstream interventions need to be evaluated in the longer term and effect greater impact (e.g. by using different intervention strategies). It may take years before actions on midstream environments translate into improved health or reduced health disparities.

The six intervention studies included in our project used income as an indicator of inequities. However, income is not the only indicator of inequities. We suggest using the PROGRESS-Plus framework[29,30] as a way of standardizing the examination of inequities. The framework outlines various measures of inequities, and is incorporated into the Equity Checklist for Systematic Review Authors authored by Ueffing et al. for the Campbell and Cochrane Equity Methods Group.[23]

At the minimum, outcomes specific to people living in conditions of disadvantage need to be reported. However, inequities are based on underlying differences. Therefore, the evidence base could be improved with studies that compare outcomes for people living in conditions of disadvantage versus people living in conditions of comparative advantage, either as groups or across the gradient. If inequities are reduced, people living in conditions of disadvantage would improve at a greater rate than those living in more advantaged conditions. At the least, interventions should not contribute to an increase in inequity. None of the six interventions in the present project compared outcomes between groups or across the gradient (some did, however, compare outcomes with a low-income control group).

Conclusion

Our project focussed on midstream interventions for obesity prevention. We recognize that such interventions are only part of a larger societal effort to reduce health inequities. The worldwide obesity epidemic is not caused by a single factor or domain (e.g. society, culture, technology, physical or natural environment), but by combined effects of the interaction of multiple factors and changes in the environment.[31] Multi-scale, intersectoral approaches are needed to tackle health inequities[15,32] and prevent chronic diseases.[33] We hope our approach to identifying effective, equity-focussed interventions contributes to a growing evidence base that translates into action to reduce inequities and improve quality of life for all.

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Conflicts of interest

The authors have no current or anticipated conflicts of interest.

Authors' contributions

Each author contributed equally to the conceptualization, compilation and writing of the report.

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Bonhoeffer J, Kochhar S, Hirschfeld S, [...] **Pless R**, et al. Global alignment of immunization safety assessment in pregnancy - the GAIA project. Vaccine. 2016;34(49):5993-7. doi: 10.1016/j.vaccine.2016.07.006.

Pham MT, **Waddell L**, Rajic A, Sargeant JM, Papadopoulos A, Mcewen SA. Implications of applying methodological shortcuts to expedite systematic reviews: three case studies using systematic reviews from agri-food public health. Res Synth Methods. 2016;7(4):433-6. doi: 10.1002/jrsm.1215.